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EVALUATION OF CATCHBASIN PERFORMANCE FOR URBAN STORMWATER POLLUTION CONTROL

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Grant No. R-804578

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16. ABSTRACT

This report summarizes the results of a field oriented data collection effort aimed at evaluating the performance and utility of catchbasins from a pollution control standpoint. The project was functionally divided into three phases, with the first being field data collection efforts and the last relegated to data reduction and analysis.

In the first phase of field work, three catchbasins in the West Roxbury section of Boston were selected from a candidate list over 40 sites throughout the city. The catchbasins chosen illustrated a diversity of land use and traffic situations, as well as design type. Each catchbasin was then cleaned using traditional methods. Subsequent to cleaning four runoff events were monitored at each catchbasin to evaluate performance. Monitoring included: influent, effluent, sump liquid and sump sediment. Catchbasin pollutant removals were found to vary widely, from a minus ten percent (discharging prior sump accumulations) to a positive 90 percent, dependent on rainfall intensity and duration. On the whole, catchbasins were shown to be quite effective for solids reduction, in the order of 60-97 percent. Catchbasin removals of associated pollutants such as chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were also significant, on the order of 10-56 percent and 54-88 percent, respectively.

The second phase of work involved the addition of an inlet strainer to each of the catchbasins as accomplished in European practice. The inlet strainers were comprised of a number of 8 mesh (0.0937 in./2.36 mm) brass screen, permanently mounted on an aluminum backing plate. Runoff for an additional three events was monitored at each site during this phase of work. Inlet strainers were found to provide a marginal increase in pollutant removal (up to ten percent), in addition to that generated by the catchbasin. One interesting phenomenon was observed, in that significant accumulations of dirt, leaves, grit and paper were collected during dry weather periods between storms.

This work was submitted in partial fulfillment of Grant No. R-804578 by Northeastern University, under joint sponsorship of the U.S. Environmental Protection Agency and the Division of Water Pollution Control, Commonwealth of Massachusetts. This report covers the period July 1978 to April 1980 and work was completed April 1980.

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research, a most vital communications link between the researcher and the user community.

The deleterious effects of storm sewer discharges and combined sewer overflows upon the nation's waterways have become of increasing concern in recent times. Efforts to alleviate the problem depend in part upon the development of integrated technologies involving non-structural best management practices with structural storage and treatment concepts.

This report presents the summary of a field oriented data collection effort aimed at evaluating the performance and utility of catchbasins from a pollution control standpoint. Catchbasins were monitored during seven runoff events and performance assessed. During three of the events specially designed insert strainers were used to assess their efficiency.

Francis T. Mayo, Director
Municipal Environmental
Research Laboratory

ABSTRACT

This report summarizes the results of a field oriented data collection effort aimed at evaluating the performance and utility of catchbasins from a pollution control standpoint. The project was functionally divided into three phases, with the first two being field data collection efforts and the last relegated to data reduction and analysis.

In the first phase of field work, three catchbasins in the West Roxbury section of Boston were selected from a candidate list of over forty sites throughout the city. The catchbasins chosen illustrated a diversity of land use and traffic situations, as well as design type. Each catchbasin was then cleaned using traditional methods. Subsequent to cleaning four runoff events were monitored during the month of December, 1979 at each catchbasin to evaluate performance. Monitoring included; influent, effluent, sump liquid and sump sediment. Catchbasin pollutant removals were found to vary widely, from a minus 10% (discharging prior sump accumulations) to a positive 90%. On the whole, catchbasins were shown to be quite effective for solids reduction, in the order of 60-97%. Catchbasin removals of associated pollutants such as Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) were also significant, on the order of 10-56% and 54-88%, respectively.

The second phase of work involved the addition of an inlet strainer to each of the catchbasins as accomplished in European practice. The inlet strainers were comprised of a number 8 mesh (0.0937 in./2.36mm) brass screen, permanently mounted on an aluminum backing plate. Runoff for an additional three events was monitored at each site during the month of January, 1980. Inlet strainers were found to provide a marginal increase in pollutant removal (up to 10%), in addition to that generated by the catchbasin. One interesting phenomenon was observed, in that significant accumulations of dirt, leaves, grit and paper were collected during dry weather periods between storms.

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ABBREVIATIONS AND SYMBOLS

Abreviation

cf	cubic feet
cfs	cubic feet per second
cm	centimeter
cm/h	centimeter per hour
fpm	feet per minute
fps	feet per second
ft	feet
ft^2	square feet
ft^3	cubic feet
g	gram
h	hour
ha	hectare
ID	inner diameter
in/h	inch per hour
lb	pound
kg	kilograms
km	kilometer
l	liter
m	meter
m^3	cubic meter
mg/l	milligram per liter
ml	milliliter
mm	millimeter
m/s	meters per second
vs.	versus

Symbols

BOD	Biochemical Oxygen Demand (5 days)
COD	Chemical Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
VSS	Volatile Suspended Solids
WWTP	Wastewater Treatment Plant
%	Percent

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CHAPTER 1

INTRODUCTION

1.1 Foreword

The purpose of this study is outlined in Section 1.2. Background materials describing catchbasin functions and American and European design and maintenance practices are given in Section 1.3. An historical review of literature dealing with the pollution control aspects of catchbasins is given in Section 1.4. Section 1.5 contains a description of the study and report format.

1.2 Purpose of Study

Control of stormwater runoff is a problem of increasing importance in the field of water quality management. Over the past 70 years, there has been extensive use of catchbasins for coarse material removal from stormwater runoff, yet catchbasin pollutant removal effectiveness has not been evaluated in depth.

In a recent study entitled "Catchbasin Technology Overview and Assessment,"(1) it was recommended that monitoring programs should be undertaken to: 1) determine the impact of best management practices in reducing solids and other pollutant loads in surface runoff that must be collected from urban areas and, introduced to the sewer through catchbasins; 2) evaluate the effectiveness of closely monitored catchbasin cleaning programs with respect to impacts of cleaning frequency and, techniques on solids carryover as well as general pollution abatement and; 3) determine the extent to which solids deposition can be mitigated by properly designed and functioning catchbasins.

These recommendations were based on an analysis of catchbasin pollutant removal performance using secondary data synthesized from a variety of sources. Direct and concurrent measurement of influent and effluent pollutant characteristics had not been previously performed. Prior measurements included either street surface pollutant characteristics or spot grab sampling of catchbasin sump volumes.

The basic thrust of the research was to carefully monitor simultaneous influent and effluent characteristics for several catchbasins in the Boston Metropolitan area. The primary emphasis of this study focused on the characterizaton of the pollution load attenuation characteristics of a catchbasin. A secondary goal examined the pollutant reduction effectiveness of insert strainers in several catchbasins within the study area.

These devices are commonly used in European practice and have been shown effective for removing gross floatables and settleable solids, such as cigarette butts, leaves, lawn clippings and paper.

1.3 Background

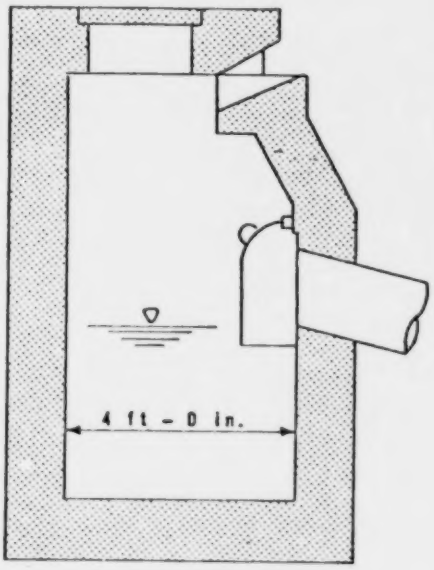
A catchbasin is defined as a chamber or well, usually built at the curbline of a street, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow. Because some communities call any device that receives stormwater a catchbasin, the distinction is made between those devices that intentionally trap sediment and those that do not. In this report, the device that traps sediment is what is referred to as a catchbasin.

Stormwater runoff in urban areas normally flows for a short period of time in the gutter and is diverted by an inlet structure leading to an underground conduit or open channel for transportation to a receiving body of water. The underground conduit, either a storm or combined sewer, may be protected from clogging by catchbasins built in conjunction with the inlets.

Catchbasins serve two main purposes: to prevent sewer gases from escaping through the inlet gratings and; to prevent heavy or large solid matter from the street from entering the sewers. The trapping of sewer gases is accomplished by a water seal. The retention of solids is achieved by providing a sump or settling basin in which the heavy solids settle to the bottom, while the light solids float on top. Water drains to the sewers through the outlet of the catchbasin which is generally a few inches below the water surface. These basins are normally built under the inlet gratings or openings, either under the gutter or just back of the curb. Occasionally, one catchbasin will serve two or more standard inlets.

In American practice, a standard catchbasin appears to be nonexistent (1). Attempts at uniformity within individual cities (Figure 1) show varying degrees of success. The effectiveness of the water seal gas trap is an important issue in American practice, since it is directly proportional to the antecedent dry period and the corresponding evaporation rate. In addition, organics in the catchbasin if allowed to accumulate, may decompose with time and contribute odors similar to sewer gas even if the water seal has not evaporated.

In Europe catchbasin sizes vary, except in Germany where they have been standardized. Two types of catchbasins are used: a simple depositary type and another type generally called



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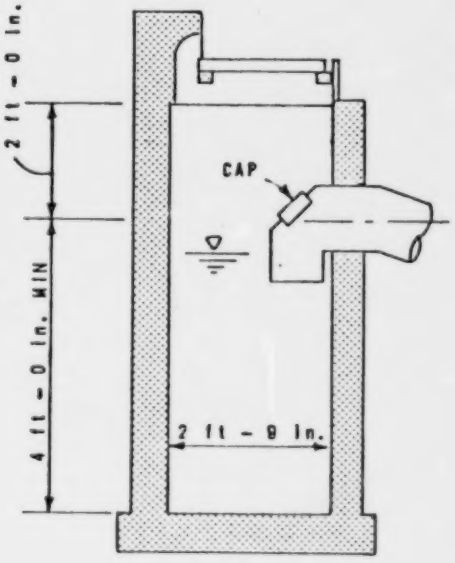

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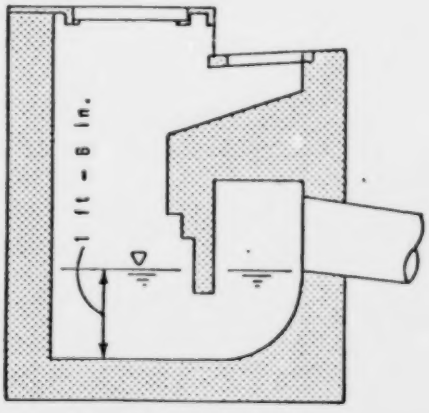

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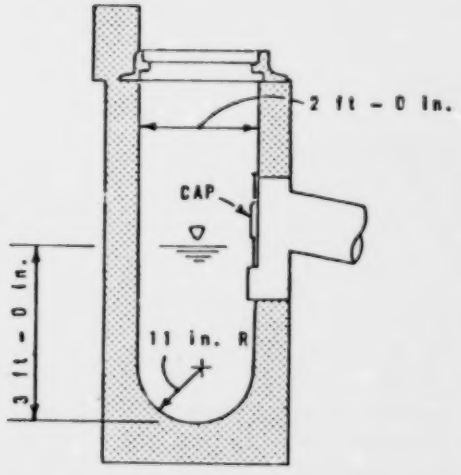


TORONTO

Figure 1. Representative catchbasin designs in the United States and Canada.
Source: Metcalf & Eddy, Inc. (1)

a "selective" catchbasin in which a bucket sieve or some other means is used to select and separate various solid materials. The latter type varies greatly in different countries and various cities. The buckets provide an easy and rapid method for cleaning by street crews. As part of this effort, inlet strainers were fabricated and installed in the monitored catchbasins to assess their pollutant removal effectiveness, thus simulating the European practice.

European catchbasins tend to be smaller in size, reflecting closer spacing, i.e., smaller drainage areas per unit. Most European cities are located on relatively flat terrain with long-duration, low-intensity, high-frequency rain patterns and most catchbasins do not include gas traps because of the frequent flushing by storm runoff. Catchbasins are usually circular in shape. A perforated removable bucket is used to catch large objects, and the runoff flow is relied on to carry the smaller material on into the sewer.

There is a definite tendency in most of the textbooks in Europe to discount, or not recommend, depository type catchbasins, because the material that accumulates with the water is subject to fermentation odors and other problems of stagnation. When depositary type basins are required, a siphon modification, in which a separation baffle is installed, is often used. The solid material is left in one compartment and the flow is basically drained through the siphon and underneath the baffle.

1.4 Historical Review

Historically, the purpose of catchbasins is to prevent sewer clogging by trapping coarse debris and to prevent odor emanations from the sewers by providing a water seal. The prevention of sewer clogging was especially important prior to the existence of good quality street pavements. In areas where streets were partially or wholly unpaved, significant quantities of stone, sand, manure and other materials were washed into the sewer system during periods of rainfall. Also, during the earlier years of sewer construction, little attempt was made to maintain self-cleaning velocities in sewers of at least .61m/s (2 fps) (2).

The usefulness of catchbasins was considered marginal as far back as 1900 (3). Most modern texts generally agree and only provide short disclaimers regarding the value of catchbasins, except where deposition of large amounts of grit is expected in the sewer without them (4,5). Despite the purported reduced need for catchbasins, they are still used widely in many parts of the country (6).

Little investigation has been conducted on the hydraulic characteristics of flow within a catchbasin. The University of Illinois conducted some investigations and concluded that catchbasins are hydraulically inefficient (7). In another study of hydraulic characteristics by the APWA, it was found that for all practical purposes complete mixing occurs within a catchbasin (8). This seems to fit in with the University of Illinois' studies which indicated that a catchbasin is a poor sedimentation device because of its tendency to resuspend the solids in the sludge deposits even at moderate inflow rates.

Attempts by the University of Illinois group to improve settling by baffling showed additional adverse effects. However, a more recent study of catchbasins with large antecedent debris contents indicated that only about one percent of the antecedent content washed out (9). It was concluded, however, that the material flushed out as the initial slug would have a substantial pollutional impact on the receiving waters. In the APWA study, it was also concluded that catchbasins may be one of the most important single sources of pollution from stormwater flows (8). All of the studies concluded that catchbasins cannot efficiently satisfy the competing objectives of good hydraulic characteristics and solids retention.

Pertinent conclusions relating to catchbasin pollutant removal effectiveness from a recent assessment study (1) are excerpted as follows:

" 1. Existing catchbasins exhibit mixed performance with respect to pollution control. The trapped liquid purged from catchbasins to the sewers during each storm generally has a high pollution content that contributes to the intensification of first-flush loadings. Countering this negative impact is the removal of pollutants associated with the solids retained in, and subsequently cleaned from, the basin.

2. The collection of conclusive field data is hindered by the prevailing poor conditions found in most basins resulting from under financed and poorly monitored cleaning programs.

3. Approximately 95 to 98% of the BOD load in the liquid contained in a catchbasin prior to a storm will be displaced to the sewer by a rainfall of as little as 0.05cm/h (0.02 in./h) lasting four hours. As a side note, the displacement of catchbasin sump volume is also dependent on the size of the tributary area as well as the rainfall intensities. This is approximately equivalent to the waste discharged by one person in one day.

4. On an annual basis, the amount of material that would be retained in a catchbasin is given in the following tabulation:

Percentage of Material Retained in Catchbasin for Individual Storm

	Range of Material Retained (Percentage)	
	Low	High
Total solids	42.1	75.0
Volatile solids	15.2	25.5
BOD5	15.5	26.6
COD	7.5	14.1
Kjeldahl nitrogen	14.6	27.4
Nitrates	9.5	17.1
Phosphates	2.3	6.0
Total heavy metals	37.4	64.4
Total pesticides	13.6	29.7

5. From a pollution abatement standpoint, the benefits of catchbasins appear limited. For example, the net removal of BOD from a well-designed and maintained system of catchbasins based on conformance to observed data, is expected to be in the range of five to 10% of the applied load. A potential exception may be the removal of heavy metals which, as tabulated above, could be significant.

All of these conclusions were reached from a desk-top analysis of data from various sources, i.e., catchbasin sump information from San Francisco and national assessments of street load solids characteristics. These results are tentative and are subject to further scrutiny using direct primary measurements from programs such as those conducted in this study."

1.5 Description of the Study/Report Format

This report details a field monitoring effort aimed at assessing the pollutant removal effectiveness of catchbasins. As mentioned in the prior sections, although catchbasins have been in use for roughly 70 years little actual monitoring of performance has been conducted and no studies have collected both influent and effluent data simultaneously. During the period of November 1979 through January of 1980 a total of seven runoff events were monitored at three separate catchbasin sites, yielding a total of 21 runoff events monitored. All of the catchbasins were located in the West Roxbury section of the city of Boston. Analyses were conducted for Total Suspended Solids (TSS), Volatile Suspended Solids (VSS), Chemical Oxygen Demand (COD),

Biochemical Oxygen Demand (5 days) (BOD), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), sediment particle sizing and, percent volatile. Special analyses were conducted to assess the sump liquid and solids conditions prior to and subsequent to the runoff events. Inlet strainers similar to those used in Europe were specially fabricated, installed and monitored over three runoff events to assess their impact on overall performances.

Site selection and details of the various catchbasins monitored are described in Chapter 4. Sample collection and analytical procedures are described in Chapter 5 and finally, monitoring results are shown in Chapter 6. Estimates of catchbasin cleaning costs in the City of Boston are presented in Chapter 7 and compared with national average results.

CHAPTER 2

CONCLUSIONS

The conclusions of this investigation are as follows:

1. Catchbasins were very effective in removing suspended solids-related pollutants from influent waste streams. Pollution mass reductions of 60 to 97 percent suspended solids, 48 to 97 percent VSS for relatively low intensity storms during December and January, 10 to 56 percent COD, and 54 to 88 percent BOD were observed. No data were obtained for summer type storms.

2. The limited data collected indicated that catchbasins do little with respect to nutrient removal.

3. Though the total mass of the influent to the catchbasins varied widely, the concentration profiles of both the influent and effluent with time were very consistent.

4. Sieve analyses of catchbasin sump sediment samplings (taken 21 times over the course of the evaluation program) yielded results consistent with those found in the literature.

5. Sump sediment was highly organic--on the order of 60 to 90 percent, depending on particle size range.

6. Inlet strainers were designed, fabricated, and installed on the three test catchbasins for three runoff events each. The strainers consistently retained significant dry weather accumulations ranging from 150 to 500 g of dry solids per day.

7. Accumulation of dry weather solids in the catchbasin inlet strainers seemed to be primarily a function of degree of vehicular traffic at each location.

8. Inlet strainers offered a slight gain in overall pollutant removal efficiency of catchbasins, but they would not be functional on a large scale. These devices are effective for the removal of course

material that could cause visual upsets. Problems with clogging and potential for decomposition and ultimate discharge of pollutants negated their value unless weekly (or more frequent) maintenance was employed.

CHAPTER 3

RECOMMENDATIONS

The following are recommendations generated from this study.

1. Catchbasins, if maintained, are an efficient pollutant reduction/maintenance tool and should continue to be utilized.

2. Similar monitoring studies such as conducted in this study should be conducted in other geographic areas to substantiate the findings of this study. Regions recommended are the midwest, south and west because of their differences in climate, hydrology and system characteristics.

3. Since energy dissipation is of prime importance to the function of catchbasins, further research should be conducted into simplistic ways of reducing influent energy.

4. Field scale demonstration of closely monitored concurrent street sweeping, catchbasin cleaning and sewer maintenance programs should be conducted in varying terrain for both separate and combined sewerage systems to investigate the optimal mix of best management practices from maintenance and pollution control viewpoints. The main emphasis of the studies should be devoted to carefully monitoring the separate and joint effectiveness of these techniques and conclude with an assessment of the impacts of cleaning frequency and mechanisms of solids carryover, general pollution abatement and associated costs.

5. Additional monitoring studies should investigate the effectiveness of catchbasins for removal of heavy metals as well as oil and grease pollutant removals.

CHAPTER 4

DETAILED CATCHMENT AREA DESCRIPTIONS

4.1 Criteria Used in the Selection of Catchbasins

Although, it would logically seem that site selection for a catchbasin monitoring program would be a simple matter, that was not the case. Prior to inspection of possible candidate sites an exhaustive review of detailed sewer maps for approximately 3000 acres of the City of Boston was conducted. This review of mapping information provided a pre-screen for candidate sites. Criteria utilized in the pre-screen were as follows: 1) All catchbasins to be monitored had to be indicated to discharge directly to a receiving manhole and not into the sewer line; 2) The catchbasin had to have a readily definable fixed tributary area and; 3) Traffic patterns and land use density had to vary. Unfortunately, it seems that most catchbasins in Boston are connected directly to the adjacent receiving sewer without access formed by a manhole. For the purposes of this study, it was deemed that access to the catchbasin discharge via a manhole connection would be most desirable for the purpose of monitoring. The catchbasin effluent sampling would be conducted at the discharge of the catchbasin to the receiving sewer in a manhole. As a result of this criteria, of the literally thousands of catchbasins within the area, a list of approximately 50 candidates were generated from the mapping review. This list was reduced to 40 potential sites on the basis of the other two criteria.

Approximately 40 catchbasins in the metropolitan area were field inspected prior to choosing the three whose performance was to be evaluated during this study. The three specific criteria used in the final selection are described below in the order of importance.

Of foremost value to the study was the selection of at least two different catchbasin design configurations. The second priority was to assure that all catchbasin catchment areas were of varying tributary acreage and more importantly, showed differences of automobile traffic density and surrounding land use. Thirdly, the physical dimensions of the catchbasin and the receiving manhole were reviewed to ensure proper space and access required for sampling equipment. The most important requirement of the monitoring manhole was adequate height between the outlet and the sewer free water surface to permit placement of a specially constructed sampling device. The receiving manhole also had to be large enough to house two sampling devices (influent

and effluent) and a discharge flow monitor. After careful review of the approximately 40 catchbasins, three test sites were chosen in the West Roxbury section of Boston.

4.2 Individual Site Descriptions

The West Roxbury section of Boston is depicted in Figure 2 and may be typified as moderate income residential, with mixed commercial occurring primarily along several main road tracts. General housing density in the area is moderate, with lawns and streets in generally good condition. The sewer system in this area is entirely separated (as constructed), with the exception of a few streets. The approximate median age of the housing in the area is 40 years. Drainage from the area discharges primarily into the Upper Charles River through an extensive drainage system. Topography in the area varies from moderately hilly to flat.

The three catchbasins selected for the study, which are shown in Figure 3, are located on the corners of Spring and Alaric Streets, Baker Street and Joyce Kilmer Road and Glenhaven Road and Keystone Street. Each site area is described in detail below.

The catchbasin at Spring and Alaric Streets is of a different configuration than the other basins selected. Whereas the other two catchbasins selected are comprised of single sumps, this design utilized a double sump arrangement. Figure 4 is a diagram of the catchbasin. Gutter flow is initially collected by a shallow basin with a non-trapped outlet pipe, eight inches in diameter, discharging the flow into a oval shaped settling basin approximately three feet by four feet in plan and 3 1/2 feet deep. The sump under the curb measures 24 inches square with six inches of depth beneath the discharge inlet. The grates covering all the selected catchbasins are square with lengthwise slits averaging two inches in width.

The area tributary to the Spring Street site is shown in Figure 5 and equals approximately 3.42 acres. The area along Spring Street is characterized by eight old large single family houses and a mechanic's garage. Open space comprises about 30% of the catchment area along Spring Street. The drainage area along Alaric Street and Alaric Terrace represents about 27% of the total catchment area. The street slope is about 20%. Traffic on Alaric street is light and services a very small residential area. Conversely, Spring Street is a major commercial four-lane traffic route with parking on both sides of the street. The area is generally littered with paper and other debris and exhibited high rates of grit accumulation over short periods of time.

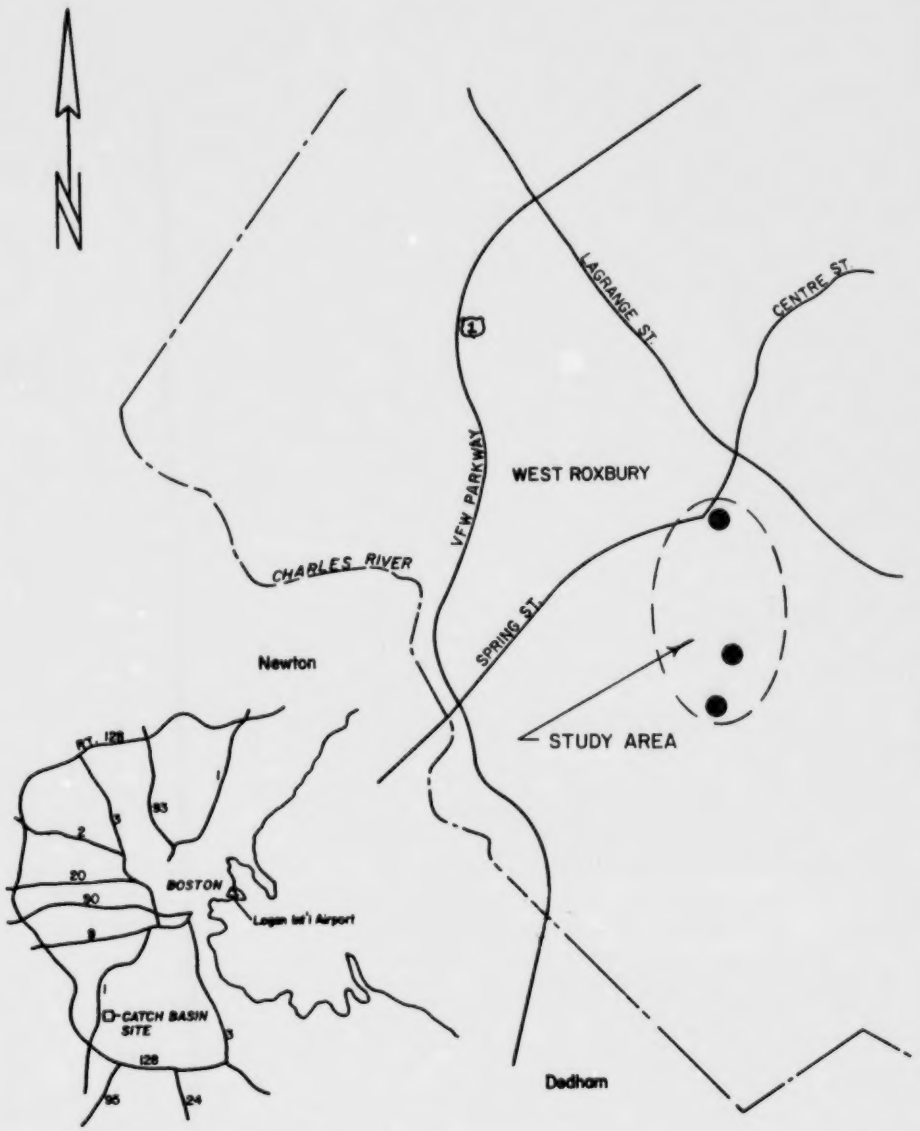


Figure 2. Locational map of West Roxbury.

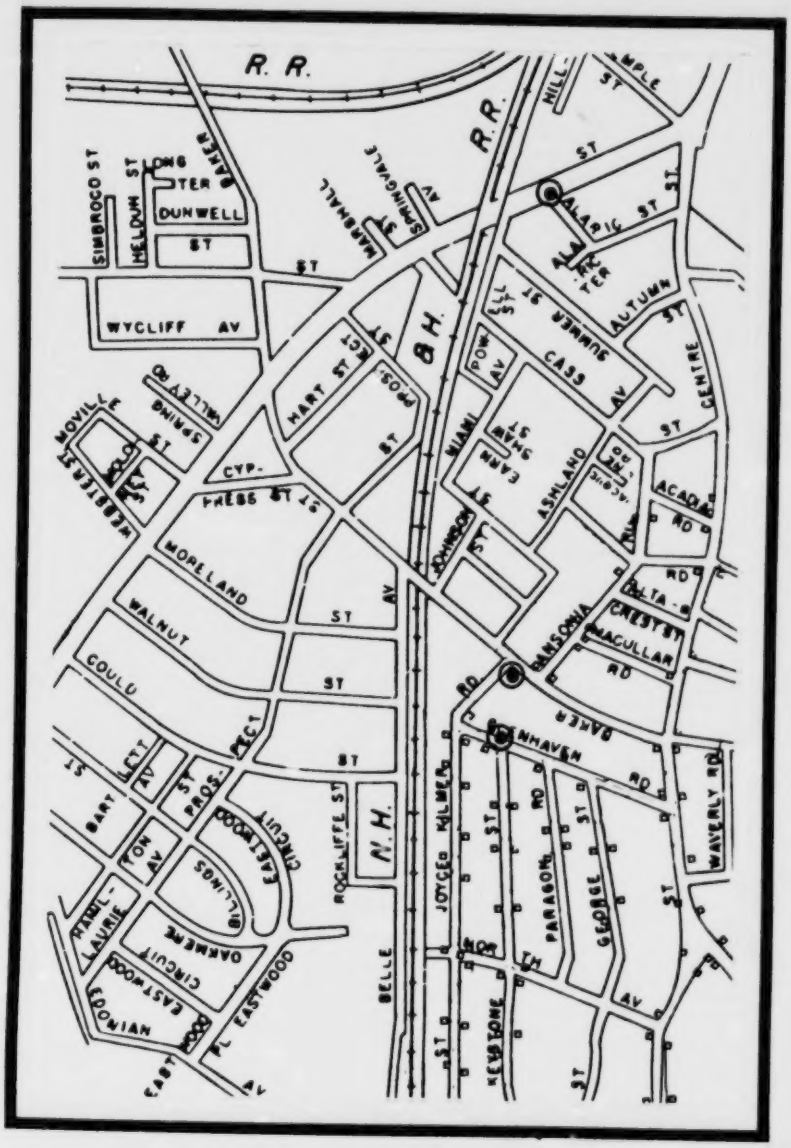


Figure 3. Locational map of catchbasin monitoring sites.

LEGEND
Monitoring site
Catchbasin
Scale
meters 0 100 200 300
feet 0 400 800

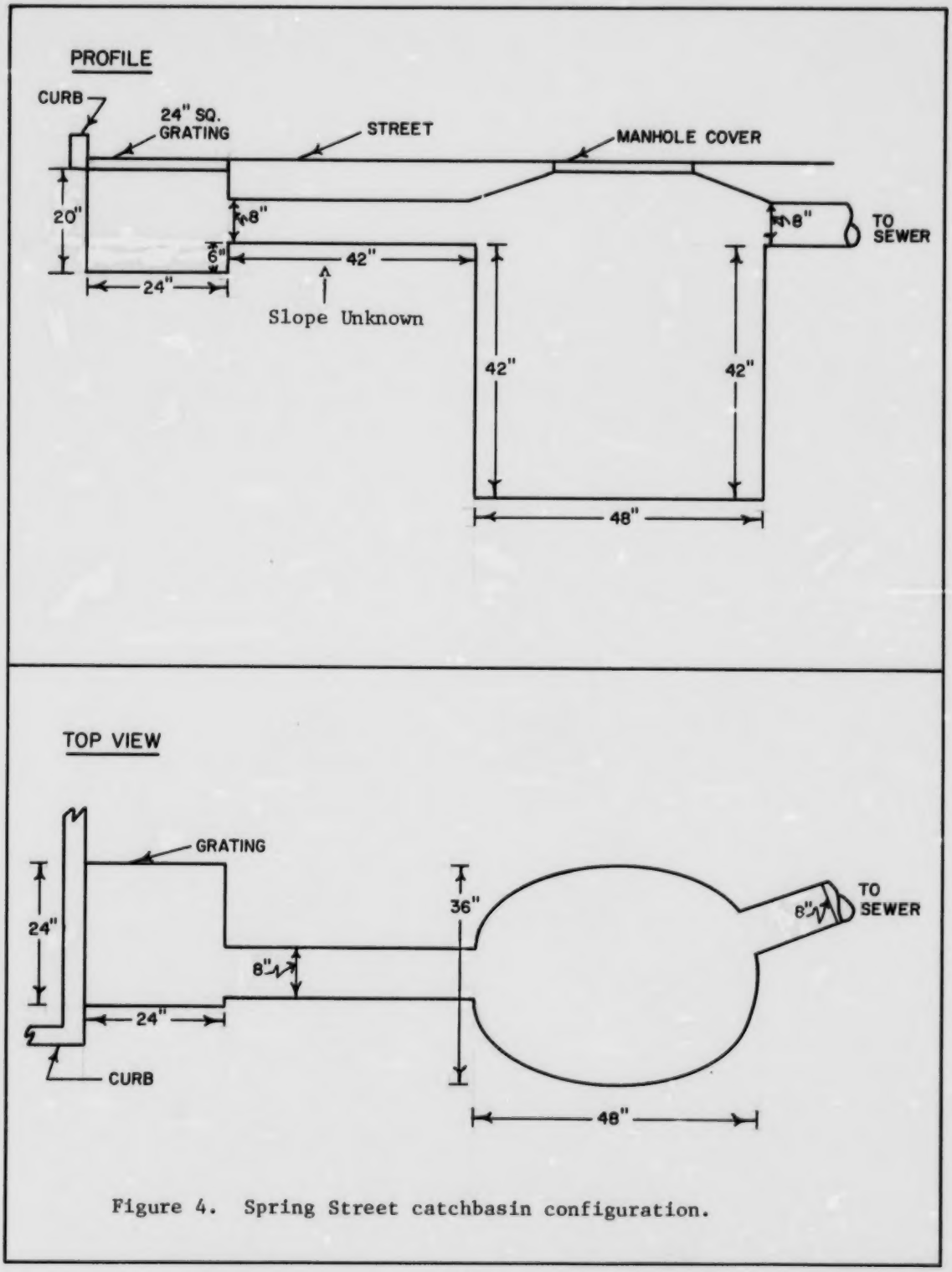


Figure 4. Spring Street catchbasin configuration.

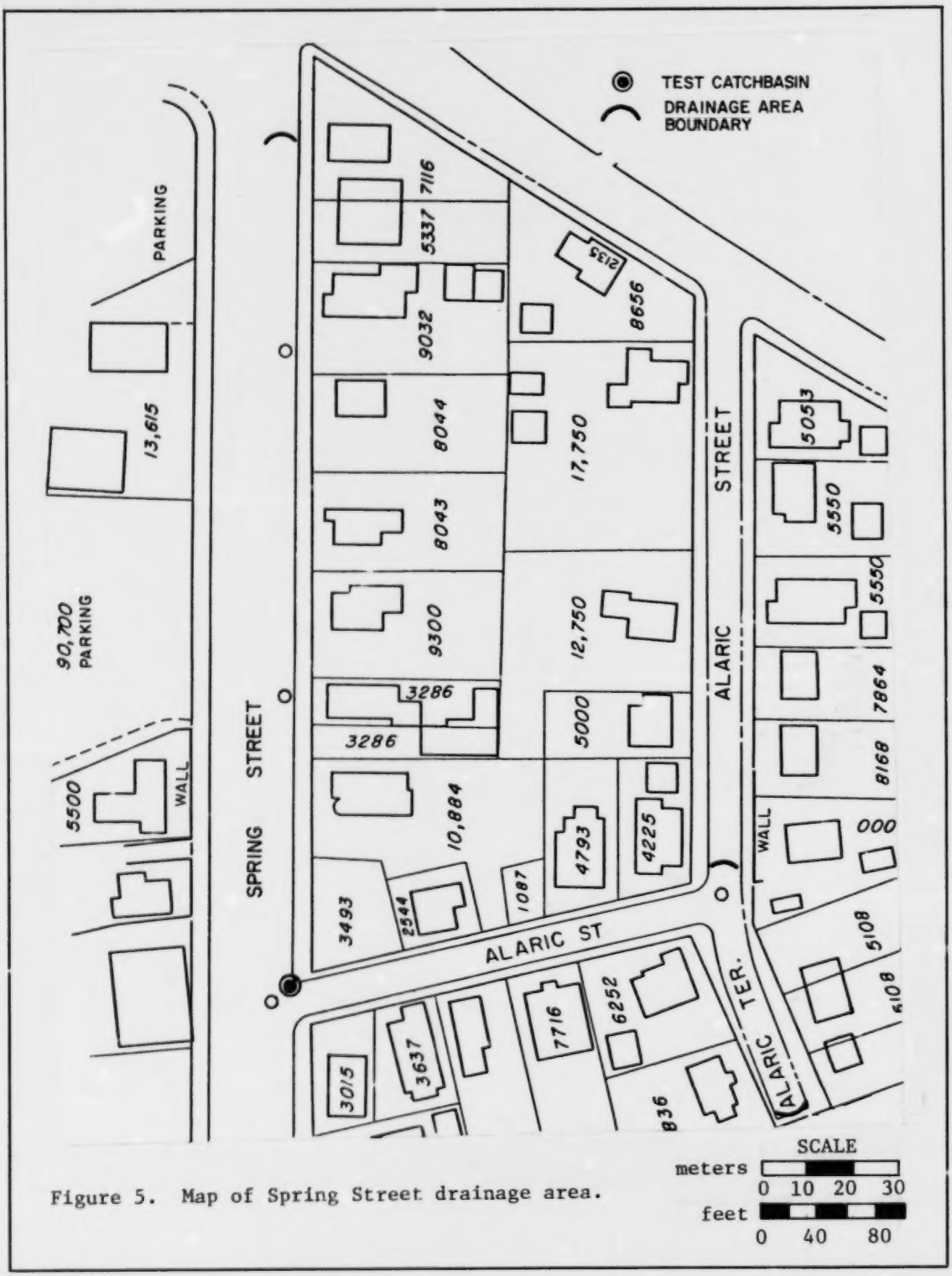


Figure 5. Map of Spring Street drainage area.

The catchbasin design of the sites on Baker Street and on Glenhaven Road (Figure 6) are very similar and conform to the typical configuration referred to as the SAN FRANCISCO style. The only difference between the basins other than capacity, is how gutter runoff enters the sumps. The Baker Street site has a brick table constructed one foot below the street grating. Runoff then drops from this table to the water surface, approximately two feet below. The sump is oval shaped (four feet by 4-1/2 feet) and drops 3 feet below the invert of the outlet pipe. The outlet pipe diameter is eight inches.

This site is the smallest area in tributary acreage as shown in Figure 7.Vehicular traffic is moderate in comparison to observed traffic along Spring Street. Total catchment area size is approximately 1.56 acre. Flow to the catchbasin comes from only one direction, on Baker Street. The street is a two-laned, medium-traveled secondary road. It is without curbstones for 75% of its length; however, the pavement over this area is continuous to the sidewalk. General condition of the pavement is very good.

The Baker Street catchment area's land use is shown in Figure 8 and is characterized by eleven small single family dwellings with lawn areas averaging 300 square feet and single car paved driveways. Few trees and bushes grow near the roadside. On-street parking is exhibited to a relatively high degree due to two factors. First, many households own two automobiles, but have driveway space for only one. Second, a pre-elementary school is located on the opposite side of the street, responsible for increasing daily children delivery and pickup parking. School bus traffic to the school comprises the only heavy vehicle traffic on Baker Street. Overall street appearance is always very clean.

The catchbasin at the Glenhaven Road location is of the SAN FRANCISCO type catchbasin design. The sump is located directly below the street grating, with a five-foot drop from the street to the water surface. The capacity of this sump is greater than the other two catchbasins, measuring 5-1/2 feet in diameter and dropping five feet below the eight-inch outlet pipe invert. Flow to the catchbasin comes from both ends of Glenhaven Road, yielding a total tributary area of 1.21 acre. Glenhaven Road is located within a residential area with only light vehicular traffic. Vehicular traffic is slight in comparison to observed traffic along Spring Street. The entire area is curbed and has paved sidewalks. Many large older trees line both sides of the street, yielding a very high leaf and twig concentration in the catchbasin sediment. Street pavement is in good repair.

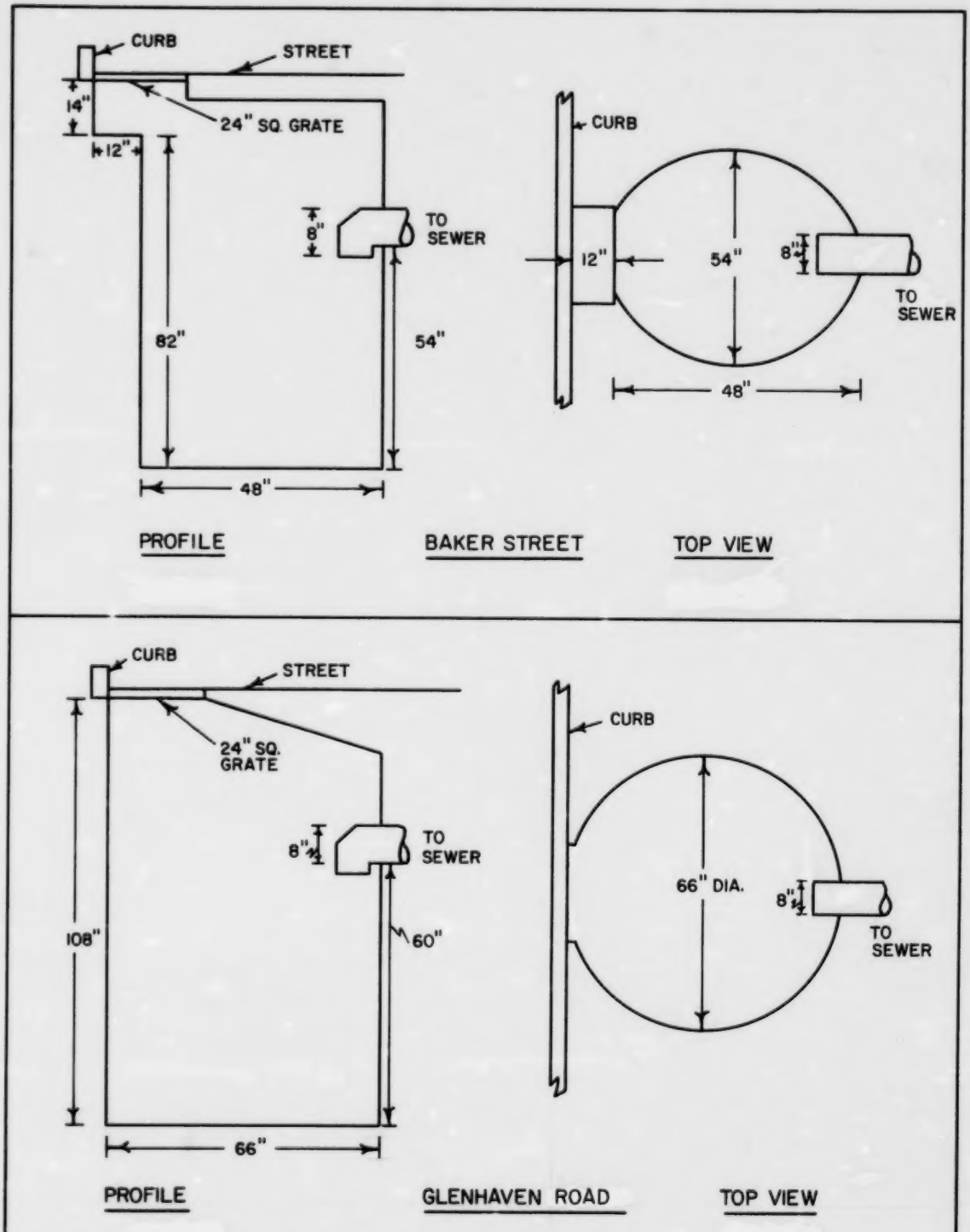


Figure 6. Baker Street and Glenhaven Road catchbasin configurations.

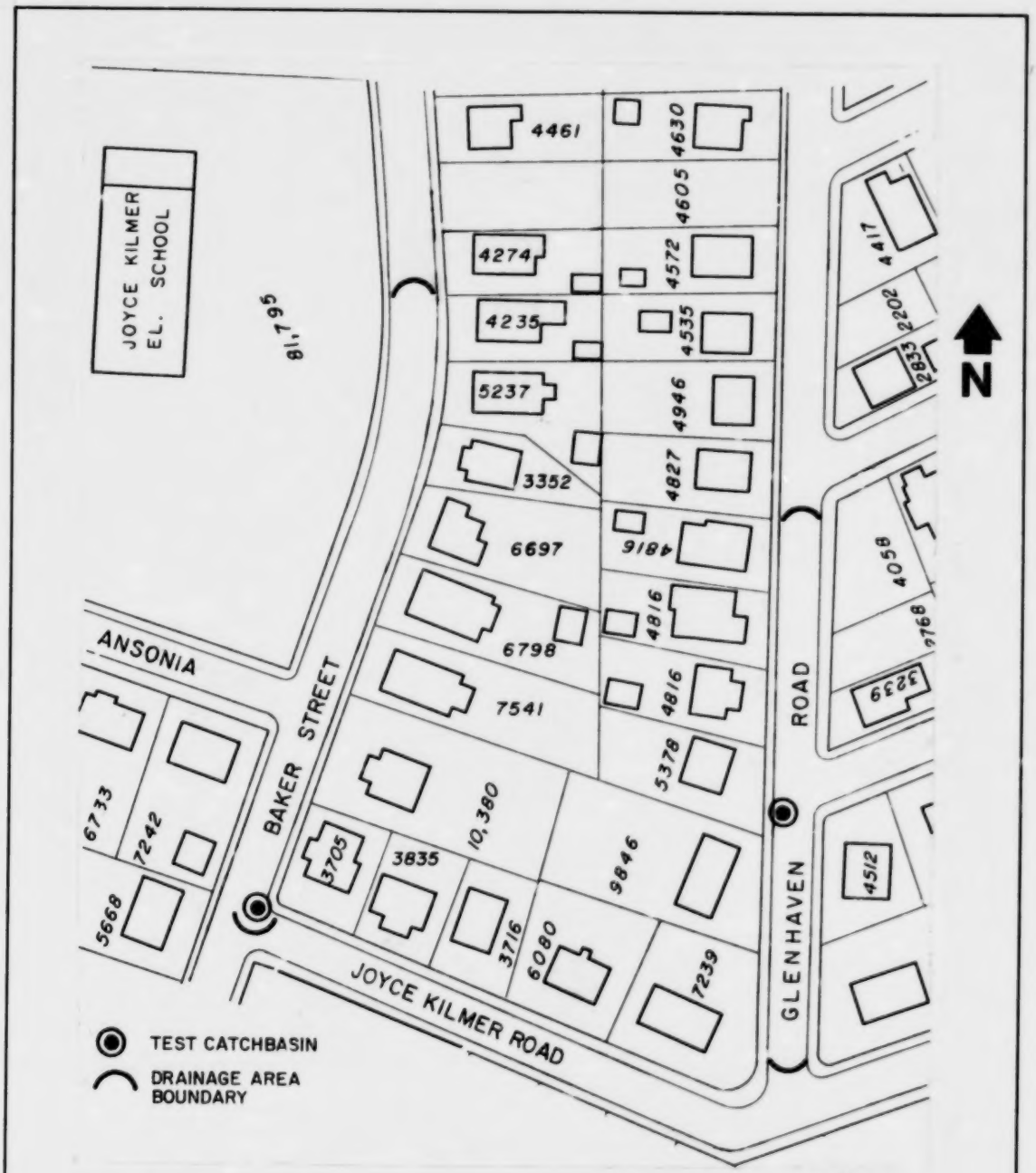
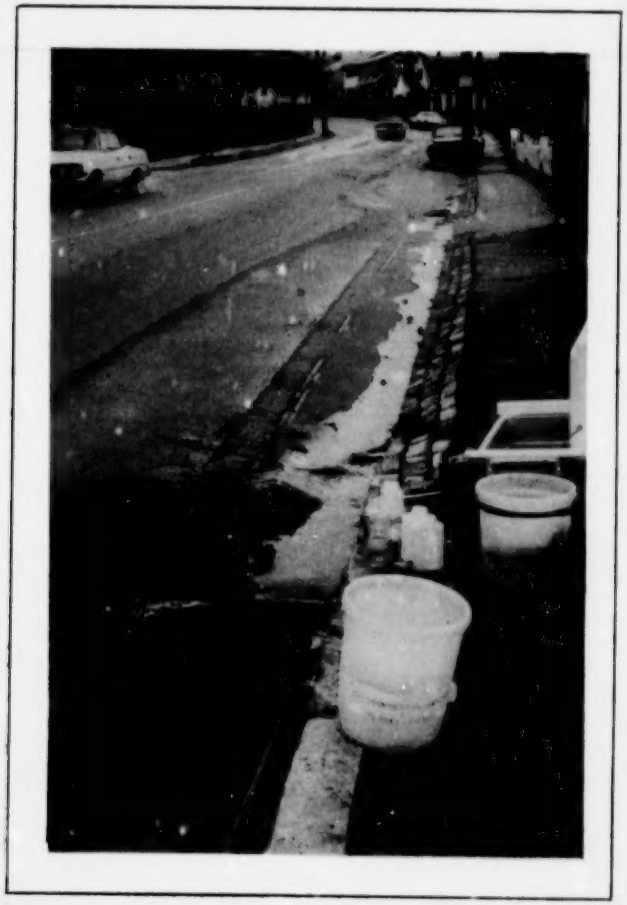
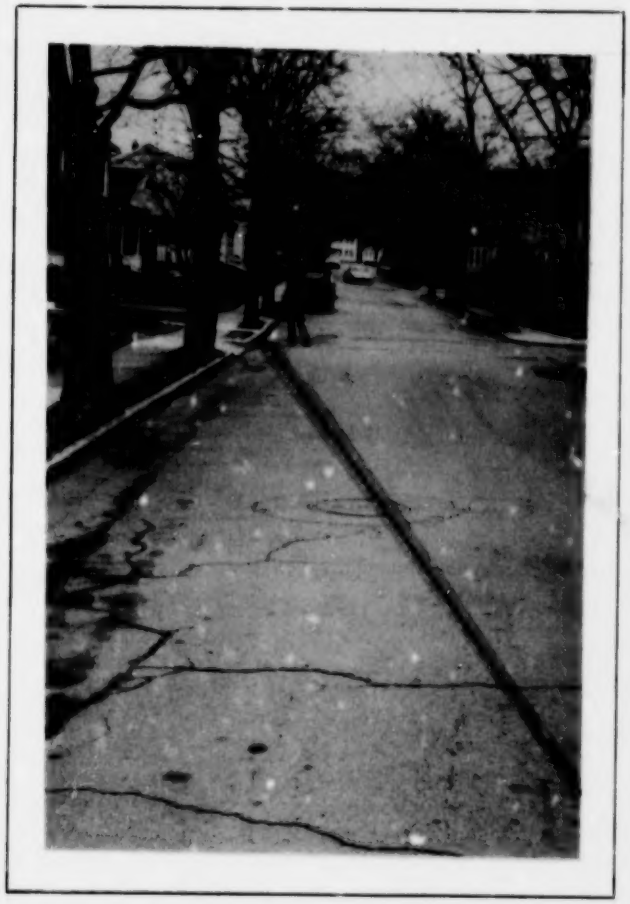


Figure 7. Map of Baker Street and Glenhaven Road drainage areas.



Baker Street catchment area



Glenhaven Road catchment area

Figure 8. Photographs of Baker Street and Glenhaven Road catchment areas.

CHAPTER 5

SAMPLE COLLECTION AND ANALYTICAL PROCEDURES

Introduction

Successful monitoring of catchbasin performance required sampling from several waste streams containing relatively high amounts of grit and floatable material. In order not to bias the catchbasin performance results, a series of special devices were fabricated to allow for representative sampling of the various waste streams. This chapter outlines the various sample types and procedures used in the field, as well as analytical procedures utilized in the laboratory.

5.1 Field Sampling Procedures-Liquid Samples

The catchbasin monitoring program was designed to collect representative and simultaneous influent and effluent samples, to assess true pollutant removal performance. As mentioned in Chapter 4, considerable effort was expended in selecting catchbasins suitable for monitoring. Prior to the initiation of the sampling program, each catchbasin was cleaned by the Boston Water and Sewer Commission cleaning crews, using typical clamshell bucket equipment. No attempt was made to further clean the catchbasins beyond that accomplished by the clamshell bucket, since the purpose of this study was to assess the effectiveness of catchbasins on a" real life" basis. Clamshell bucket cleaning equipment is the most predominate type used in the United States for catchbasin cleaning and although convenient, is not totally effective. Subsequent to cleaning, each catchbasin had at least 12 inches of residual materials on the bottom and substantial accumulations stuck to the sidewalls of the sump. Undoubtedly, the remaining residuals effected the overall catchbasin performance.

Figure 9 depicts the sampling and analytical procedures used for the various liquid samples taken. As may be noted from the figure, samples taken included: sump grab sample prior to runoff event (pre-sump sample); gutter or influent samples at the inlet to the catchbasin during storm event; effluent samples taken at the outlet to the receiving sewer manhole during storm event and finally, samples taken in the sump subsequent to the runoff event (post-sump sample). Sampling of the various liquid sample types were conducted for all runoff events at the three catchbasins monitored.

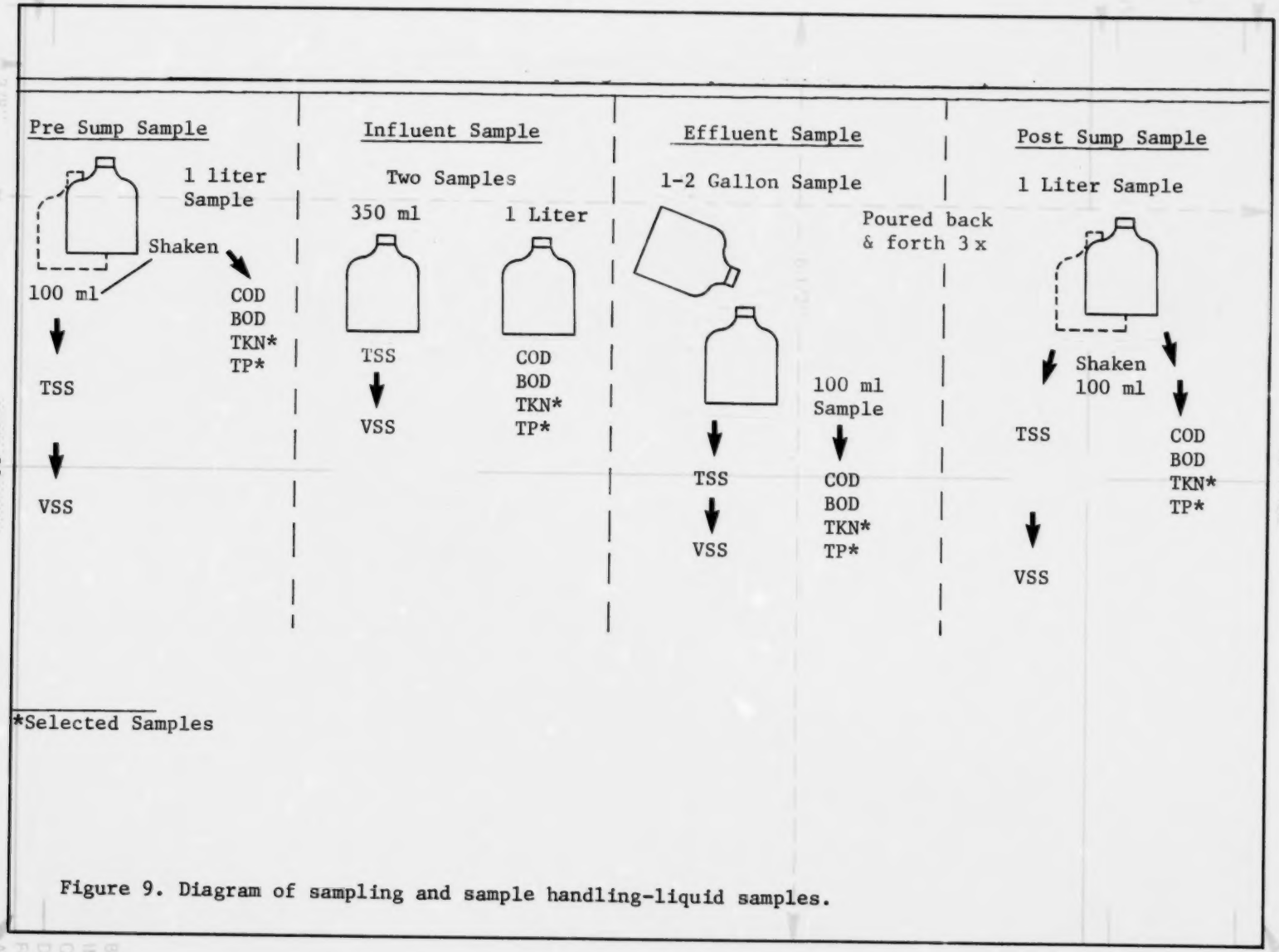


Figure 9. Diagram of sampling and sample handling-liquid samples.

Initially, the primary thrust of the catchbasin monitoring program was to be conducted by automated sampling and flow gaging equipment. Since both the influent and effluent samples would have significant fractions of grit and since commercial sampling equipment will not adequately capture grit, special sampling equipment had to be designed. The special sampling equipment was in essence, a mechanical grab sampler. Monitoring of the influent utilized a specially constructed mechanical scoop to take gutter samples and discharge them directly into the appropriate sample bottle in a sample bottle cassette. Effluent samples were collected by passing a sampling scoop through the free effluent discharge into the receiving sewer manhole, collecting a complete "slice" of the discharge volume and discharging the collected fraction into a sample bottle in a sample bottle cassette.*

During the sampling program both automated and manual techniques were employed. Since EDP field crews were able to be onsite during most of the runoff events, grab sampling techniques were used for those events. The grab sampling procedures employed are shown in Figures 10 and 11.

Figure 10 shows the pre-sump sampling procedure. A specially designed sample bottle holding device was constructed for this purpose to allow obtaining cross sectional sump samples. Initially, a sample bottle was loaded in the device and the trigger released, tightly sealing the bottle closed. The bottle was then lowered in the sump to the appropriate depth(s) and the trigger mechanism pulled, allowing the bottle to fill. At any time, release of the trigger mechanism would close off the sample bottle, allowing movement to another position for cross-sectional sampling. The post-sump sample was taken in a similar manner as the pre-sump sample (within two to five minutes of cessation of runoff).

Grab sampling of the gutter influent and catchbasin effluent flow is shown in Figure 11. Grab sampling of the gutter was accomplished by collecting a cross section of the flowing gutter materials and depositing the contents into a sample bottle. In all cases the gutter area where samples were taken was maintained clean prior to runoff events, to ensure no sampling bias. Influent grabs were taken via a series of scoopings deposited into two bottles, as shown in Figure 9. Due to the great difficulty in obtaining a thoroughly mixed 100 ml fraction of a one liter sample, a single 350 ml sample was used for the suspended solids determination. The second sample was used for the determination of all other parameters.

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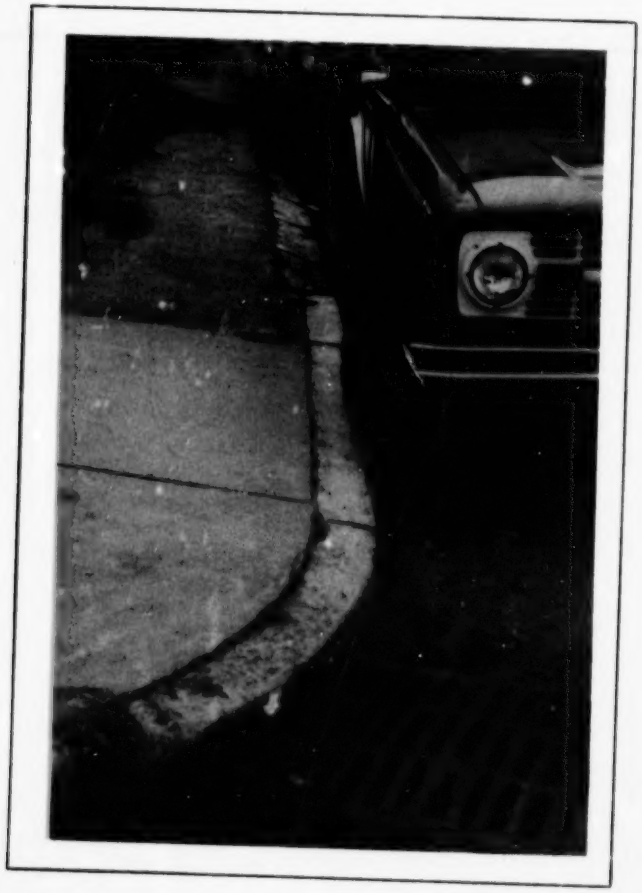
* It should be pointed out that even this method of sampling would not account for the slower movement of the particulate

(Foot note continued on top of page 26)



Catchbasin at Spring Street

Technician taking pre-sump sample at Baker Street

Figure 10. Photograph of catchbasin at Spring Street and pre-sump sampling at Baker Street.

Collection of gutter grab samples

Collection of full volume effluent samples

Figure 11. Gutter and effluent grab sampling procedure.

*flowfield compared to the liquid flowfield and samples are only taken for an instantaneous period of time as opposed to throughout the entire influent - effluent period. These deficiencies disallow totally representative sample collection.

Effluent grab sampling and flow monitoring was accomplished by suspending a sampling pail beneath the discharge of the catchbasin to the receiving sewer manhole for a timed period. In this manner, both flow and quality were determined simultaneously. The total volume sampled was returned to the laboratory for analysis. The total volume collected and measured per sampling interval was divided by the collection time to yield flow rate. The collected effluent sample, in the order of one to three gallons, was then mixed by pouring from one pail to another three times. During the final pouring, an approximately 100 ml sample was decanted rapidly into a graduated cylinder for the suspended solids determination. All other parameters analyzed for were determined from samples drawn from the large pail.

Table I presents a summary of the analytical procedures used during the catchbasin monitoring program. Replicate analyses were performed every sixth to eighth sample for all collected sets.

TABLE I

SUMMARY OF ANALYTICAL METHODS

Parameter	Analytical Methods
Suspended Solids	Total Residue Dried at 103-105c S.M. 208A*
Volatile Suspended Solids	Total Volatile and Fixed Residue at 550c S.M. 208E
Total Kjeldahl Nitrogen	Nitrogen (Organic) S.M. 421
BOD	Oxygen Demand (Biochemical) S.M. 507
Total Phosphate	Preliminary Digestion for T.P. S.M. 425c
	Stannous Chloride Method S.M. 425E
COD	Oxygen Demand (Chem.)** Ampule COD Method

* (10) Standard Methods for the Examination of Water and Wastewater 14th Edition, 1975 APHA-AWWA-WPCF.
** (11) OCEANOGRAPHY INTERNATIONAL CORP. E.P.A. approved Alternative Method Federal Register Vol. 43, No. 45, Tues., March 7, 1978.

5.2 Field Sampling Procedures-Solids Samples

5.2.1 Sump Sediment Samples

Prior to each runoff event the level of sediment in the catchbasin sump was measured and then sampled. Samples were taken by means of a cross sectional scooping as depicted in Figure 12, to assure a representative sample. Each sediment sample so collected was then air dried, weighed and then a sieve analysis conducted. The sieve series employed was the following:

TABLE 2

SIEVE SERIES UTILIZED FOR SUMP SEDIMENT ANALYSIS

Standard Sieve Number	Size Opening inches	mm
8	0.0937	2.36
16	0.0469	1.18
30	0.0234	0.600
50	0.0117	0.300
100	0.0059	0.150
200	0.0029	0.075
Pan		

Subsequent to the sieve analysis, each sieved fraction was fired to conduct a percent volatile analysis. All procedures followed the prior referenced "Standard Methods".

5.2.2 Inlet Strainer Samples

Inlet strainers were fabricated and installed to assess their additional pollutant removal benefit on catchbasins. A typical inlet strainer is shown on Figure 13. The inlet strainers were constructed of United States standard number 8 mesh brass screening (0.0937 in., 2.36 mm), attached to an aluminum plate. Samples from the first four runoff events were collected without the use of inlet strainers. Subsequently, samples from three additional events were monitored using the inlet strainers. Two types of samples were collected from the strainers; 1) accumulations occurring during the dry period between sampled events and 2) accumulations generated during the runoff events.

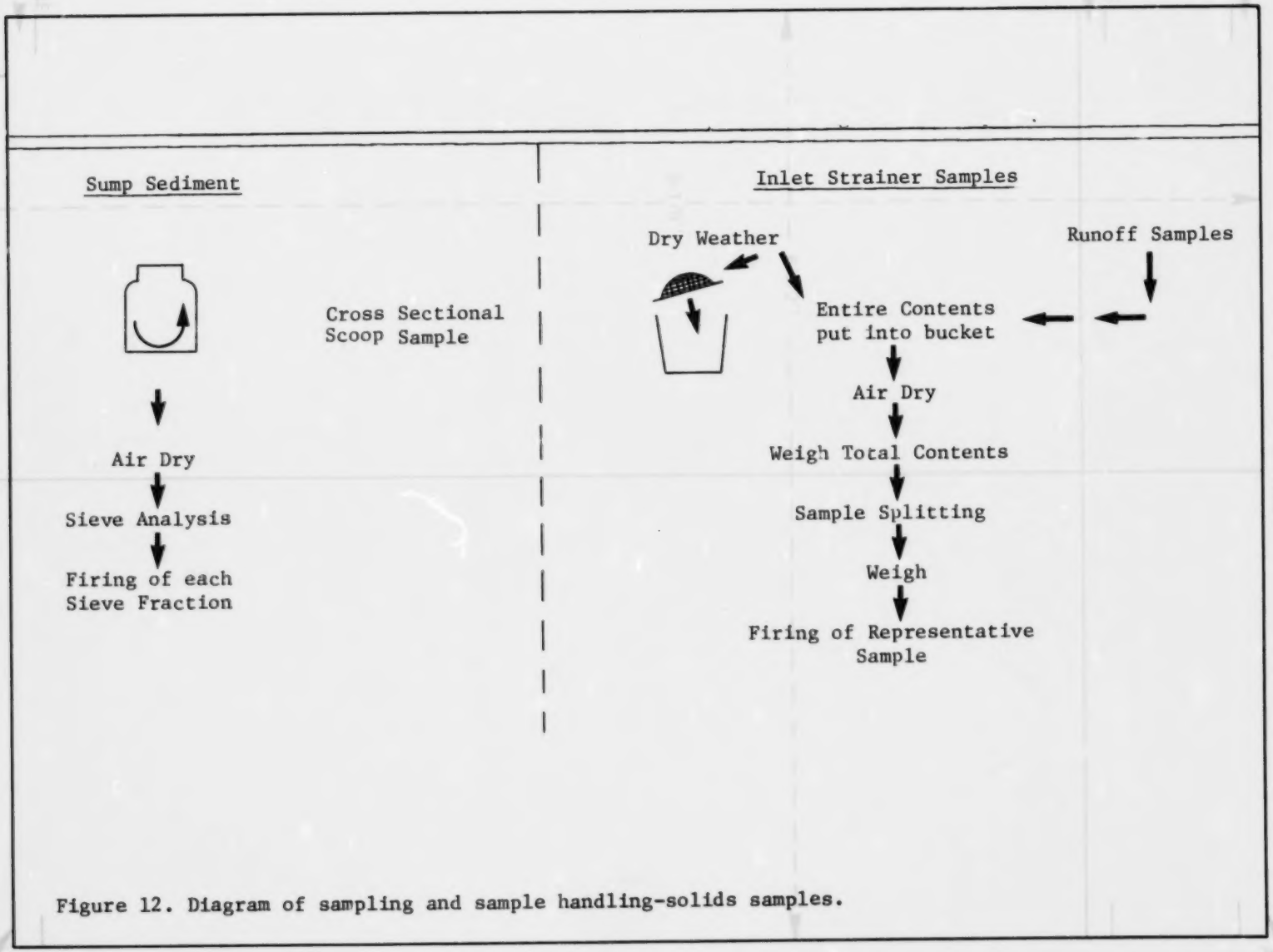


Figure 12. Diagram of sampling and sample handling-solids samples.

Strainer bag insert

Typical dry weather collected debris

Figure 13. Photographs of inlet strainer unit.

The field procedure was such that the inlet strainer was left in place between events. Prior to an impending event, the inlet strainer would be removed from the catchbasin and all contents put into a collection pail for transport to the laboratory. The inlet strainer would then be reinstalled into the catchbasin for collection during the event itself. Subsequent to the runoff event, the inlet strainer would again be removed and all contents put into a separate collection container for subsequent analysis. All samples so collected were then air dried, weighed and a representative fraction fired (same procedure as VSS analysis), to ascertain total mass collected and percent volatile. Figure 14 is a photograph of debris collection in an inlet strainer and collected debris in the laboratory.

5.3 Other Field Determinations

Monitoring of precipitation during a runoff event was conducted using an automated recording rain gage located adjacent to the site. Additional depth and velocity measurements were taken in the gutter during runoff events to provide additional flow data.

Wet weather debris collection

Dry Weather debris collected

Glenhaven Road Baker Street Spring Street

Figure 14. Photographs of debris collection and collected debris from strainer bag.

CHAPTER 6

RESULTS OF THE CATCHBASIN MONITORING PROGRAM

Introduction

A total of seven runoff events were monitored during the period of December 5, 1979 - January 14, 1980. The first four events were monitored without inlet strainers and, the last three with them in place. The following Chapter presents a summary of results of the catchbasin monitoring program. Section 6.1 presents a summary of results for all stations including: chronology, sump sampling data and all water quality data collected. Section 6.2 presents the results of the sump sediment testing program. Influent strainer results are presented in Section 6.3 and finally Section 6.4 presents a review of findings.

6.1 Summary of Results-Liquid Samples

A chronology of the catchbasin monitoring program is shown in Table 3. As may be noted from the table, the total program extended from December 5, 1979 through January 29, 1980. During that period a total of nine runoff events occurred, of which seven were sampled, plus one minor snow melt occurring December 14-16. Tables 4-24 present all water quality data generated during the catchbasin monitoring program. Average flow rates for each of the measured runoff events are shown in Table 25. Two points of interest may be generated from the table; 1) the average flows measured tended to be somewhat lower than expected and 2) runoff to each catchbasin was proportional to catchment area. The first point of interest is most important in assessing the data presented in this chapter. Given the tributary areas and probability of various intensity events in the Boston area, runoff to the catchbasins in the order of 0.01-0.12 cfs would be expected. All of the average flows measured were in the range of 0.013 - 0.05 cfs. Average runoff correlated reasonably with average rainfall. Lower flow rates would naturally yield less turbulence in the catchbasin and, ideally correspondingly higher removals.

Table 26 is a summary of the total computed mass and pollutant removals measured during the first four runoff events at each location. These data represent events without the use of inlet strainers. As may be noted from the data in the table, very high removals of solids ranging from 60-97% were evidenced. Correspondingly high removals were observed for VSS (48-97%), COD (10-56%) and BOD (54-88%). Although some negative removals were observed for all parameters except VSS, the overall solids

TABLE 3. CHRONOLOGY OF CATCHBASIN MONITORING PROGRAM

Date		
12/5/79	Runoff event monitored	Moderate intensity/short duration
12/7/79	" " "	(Average intensity = 0.09 in./h)
12/12/79	" " "	(Average intensity = 0.06 in./h)
12/14/79	Snow	(Average intensity = 0.08 in./h) Approximately one inch
12/14/79	Snow Melt	
12/25/79	Runoff event	Nighttime precipitation 0.33 in. cyclic periods of high intensity long duration
12/27/79	Runoff event monitored	Rain gage inoperative
12/28/79	Insert strainers installed/runoff event monitored	(Average intensity = 0.11 in./h)
1/11/79	Runoff event monitored Insert strainers installed	Late night storm high intensity 0.49 inch rain - short duration (rain gage inoperative)
1/14/80	Runoff event monitored Insert strainers installed	(Average intensity = 0.09 in./h)
1/29/80	Insert strainers removed	

TABLE 4. CATCHBASIN MONITORING DATA
LOCATION SPRING STREET
EVENT DATE 12/5/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/1	COD mg/1	TSS mg/1	VSS mg/1	TKN mg/1	TP mg/1
INFLUENT	0.0	-	730	10167.2	1382.2	5.0	0.48
	0.5	132	465	4396.4	498.3	-	0.56
	1.0	72	370	2085.7	170.8	5.6	0.32
	1.5	52	235	1805.4	167.8	-	0.18
	2.0	42	185	1320.0	130.9	-	0.17
	2.5	27	210	1426.9	145.8	5.0	0.24
	9.0	11	45	798.2	57.1	2.1	0.08
	16.0	12	60	303.5	25.2	-	0.10
	17.0	17	55	267.8	27.7	-	0.05
	18.0	12	25	491.4	57.7	-	0.09
	19.0	-	10	465.9	63.7	-	-
EFFLUENT	16.0	122	235	1097.7	241.1	7.4	0.37
	17.0	112	130	1168.6	265.9	-	0.30
	18.0	-	180	578.1	87.7	-	0.24
	19.0	75	95	659.0	143.2	6.0	0.24
	20.0	57	155	369.2	51.7	-	0.17
	21.0	62	130	406.4	55.1	-	0.18
PRE-SUMP		-	130	1097.7	241.1	-	0.12
POST-SUMP		-	-	-	-	-	-

* Time since start of storm

TABLE 5. CATCHBASIN MONITORING DATA
LOCATION BAKER STREET
EVENT DATE 12/5/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l	TKN mg/l	TP mg/l
INFLUENT	0.0	270	540	1146.5	167.7	9.2	0.18
	0.5	252	540	1041.4	126.8	-	0.50
	1.0	317	565	795.7	103.4	-	0.22
	1.5	237	555	867.0	122.4	8.2	0.24
	2.0	312	530	846.1	108.7	-	0.05
	2.5	280	525	642.3	79.5	-	0.04
	15.0	142	-	161.6	26.3	2.2	0.07
	23.0	130	165	174.2	26.8	-	0.06
	24.0	127	130	142.7	20.5	-	0.05
	25.0	117	70	103.9	18.7	-	0.06
	26.0	122	105	99.3	15.9	-	0.06
EFFLUENT	23.0	212	345	573.5	148.4	7.6	0.13
	24.0	197	335	348.0	76.2	-	0.14
	25.0	192	310	287.5	56.8	-	0.18
	26.0	187	270	243.5	52.3	3.8	0.12
	27.0	172	320	255.0	52.3	-	0.14
	28.0	217	250	241.7	51.3	-	0.14
PRE-SUMP		82	290	162.0	24.3	7.6	0.09
POST-SUMP		-	-	-	-	-	-

* Time since start of storm

TABLE 6. CATCHBASIN MONITORING DATA
LOCATION GLENHAVEN ROAD
EVENT DATE 12/5/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l	TKN mg/l	TP mg/l
INFLUENT	0.0		1075	1321.8	214.2	3.4	0.24
	0.5	86	765	636.0	83.8	-	0.10
	1.0	61	335	452.3	57.9	4.2	0.08
	1.5	52	335	214.4	24.7	-	0.06
	2.0	44	270	145.9	20.5	-	0.04
	2.5	43	180	115.5	12.8	3.6	0.03
	6.5	11	145	15.5	-	-	-
	26.0	8	25	18.1	2.4	-	-
	27.0	8	130	10.1	1.3	-	-
	28.0	7	180	7.0	-	-	-
	29.0	8	85	9.8	2.3	-	-
EFFLUENT	26.0	45	740	308.9	93.0	-	0.12
	27.0	35	500	175.5	41.7	4.7	0.15
	28.0	35	295	155.7	38.4	-	0.14
	29.0	35	260	136.4	34.4	-	0.08
	30.0	35	255	178.6	42.2	3.4	0.08
	31.0	35	255	147.3	35.9	-	0.09
PRE-SUMP		27	210	208.5	22.9	2.0	0.11
POST-SUMP		-	-	-	-	-	-

* Time since start of storm

TABLE 7. CATCHBASIN MONITORING DATA
LOCATION SPRING STREET
EVENT DATE 12/7/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	150	530	510.0	76.7
	5.0	17	180	394.9	44.0
	10.0	22	70	264.5	27.3
	15.0	9	70	198.8	21.7
	20.0	13	70	235.7	21.1
	25.0	9	130	182.5	21.4
EFFLUENT	1.0	16	295	103.8	10.5
	6.0	14	130	107.7	5.3
	11.0	22	155	228.9	19.9
	16.0	16	143	226.0	17.2
	21.0	8	85	183.8	23.3
	26.0	25	120	130.0	5.0
PRE-SUMP		20	80	77.9	-
POST-SUMP		13	255	134.5	5.9

* Time since start of storm

TABLE 8. CATCHBASIN MONITORING DATA
LOCATION BAKER STREET
EVENT DATE 12/7/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	80	880	2409.4	164.6
	5.0	55	270	222.6	27.0
	10.0	13	80	771.0	43.2
	15.0	13	-	161.5	16.1
	20.0	4	25	342.1	26.4
	25.0	5	30	128.4	15.4
EFFLUENT	1.0	42	45	50.9	2.0
	6.0	42	155	70.8	-
	11.0	45	130	62.8	-
	16.0	20	285	65.1	1.0
	21.0	26	125	51.8	-
	26.0	24	75	54.4	1.0
PRE-SUMP		20	55	4.5	6.2
POST-SUMP		21	-	54.5	-

* Time since start of storm

TABLE 9. CATCHBASIN MONITORING DATA
LOCATION GLENHAVEN ROAD
EVENT DATE 12/7/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	76	380	1075.7	267.6
	5.0	33	195	220.5	35.3
	10.0	35	80	109.1	16.8
	15.0	32	60	85.9	12.9
	20.0	32	-	83.4	12.3
	25.0	39	25	65.5	9.8
EFFLUENT	2.0	82	235	106.6	10.7
	7.0	72	155	118.3	14.1
	12.0	75	-	159.0	37.4
	17.0	76	260	101.8	7.6
	22.0	75	105	167.7	19.1
	27.0	66	70	164.6	17.3
PRE-SUMP		39	215	-	-
POST-SUMP		83	290	84.9	7.1

* Time since start of storm

TABLE 10. CATCHBASIN MONITORING DATA
LOCATION SPRING STREET
EVENT DATE 12/12/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	270	918	20017.2	6422.1
	10.0	75	118	305.4	79.0
	20.0	23	70	207.3	36.2
	30.0	19	60	187.6	15.3
	40.0	16	70	145.7	30.1
	50.0	8	50	114.9	31.3
EFFLUENT	2.0	18	215	746.4	398.1
	12.0	8	165	201.0	52.7
	22.0	4	143	260.9	70.6
	32.0	2	143	214.7	58.7
	42.0	10	95	156.9	41.6
	52.0	4	70	101.5	30.1
PRE-SUMP		20	-	32.7	15.7
POST-SUMP		36	50	99.0	28.7

* Time since start of storm

TABLE 11. CATCHBASIN MONITORING DATA
LOCATION BAKER STREET
EVENT DATE 12/12/79

SAMPLE TYPE	SAMPLING TIME * (minutes)	BOD mg/1	COD mg/1	TSS mg/1	VSS mg/1
INFLUENT	0.0	220	580	4399.8	2939.5
	10.0	20	130	346.7	45.8
	20.0	16	50	277.2	135.3
	30.0	5	70	166.7	35.8
	40.0	20	35	152.3	28.1
	50.0	28	25	110.7	27.7
EFFLUENT	2.0	12	60	132.9	43.1
	12.0	19	178	120.3	42.5
	22.0	15	143	77.9	30.3
	32.0	13	70	58.3	20.3
	42.0	11	12	58.6	22.9
	52.0	5	12	48.1	21.1
PRE-SUMP		32	53	71.2	50.0
POST-SUMP		28	60	49.9	21.2

* Time since start of storm

TABLE 12. CATCHBASIN MONITORING DATA
LOCATION GLENHAVEN ROAD
EVENT DATE 12/12/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	90	260	1814.1	1403.9
	10.0	63	50	277.3	207.0
	20.0	50	60	111.2	58.9
	30.0	48	35	73.1	33.1
	40.0	60	12	54.9	24.1
	50.0	58	12	94.9	57.2
EFFLUENT	3.0	40	480	617.3	181.5
	13.0	44	238	401.3	120.9
	23.0	31	190	238.0	77.1
	33.0	19	143	146.3	48.6
	43.0	5	118	104.9	36.6
	53.0	11	60	76.4	28.4
PRE-SUMP		24	70	89.6	46.2
POST-SUMP		92	125	70.8	27.6

* Time since start of storm

TABLE 13. CATCHBASIN MONITORING DATA
LOCATION SPRING STREET
EVENT DATE 12/27/79

SAMPLE TYPE	SAMPLING TIME * (minutes)	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	755	14299.2	4726.2
	1.0	580	1905.2	275.5
	5.0	310	791.7	169.6
	10.0	115	624.0	91.5
	15.0	83	490.6	88.4
	30.0	103	287.5	78.9
	45.0	103	234.9	97.1
	60.0	-	585.2	101.5
EFFLUENT	2.0	320	150.6	58.3
	15.0	335	142.8	53.9
	30.0	215	58.8	18.0
	45.0	125	87.2	27.4
	60.0	110	95.3	20.0
PRE-SUMP		103	-	-
POST-SUMP		130	-	-

* Time since start of storm

TABLE 14. CATCHBASIN MONITORING DATA
LOCATION BAKER STREET
EVENT DATE 12/27/79

SAMPLE TYPE	SAMPLING TIME * (minutes)	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	355	4378.5	776.6
	1.0	215	941.9	282.4
	5.0	-	232.8	57.1
	10.0	-	165.5	48.3
	15.0	90	142.1	31.5
	30.0	35	129.1	28.3
	45.0	30	-	-
	60.0	70	-	-
EFFLUENT	1.0	170	409.8	137.6
	15.0	140	346.0	86.6
	30.0	75	195.0	44.4
	45.0	70	112.2	26.7
	60.0	30	88.8	23.0
PRE-SUMP		30	-	-
POST-SUMP		70	-	-

* Time since start of storm

TABLE 15. CATCHBASIN MONITORING DATA
LOCATION GLENHAVEN ROAD
EVENT DATE 12/27/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	440	2887.4	2245.8
	1.0	220	357.8	171.6
	5.0	30	431.8	339.4
	10.0	65	113.3	42.5
	15.0	60	41.7	26.2
	30.0	30	48.2	25.5
	45.0	40	68.8	36.4
	60.0	-	50.3	20.5
EFFLUENT	1.0	20	98.9	75.3
	15.0	420	680.2	198.5
	30.0	120	192.1	65.1
	45.0	110	87.3	32.0
	60.0	70	47.4	15.0
PRE-SUMP		65	-	-
POST-SUMP		-	-	-

* Time since start of storm

TABLE 16. CATCHBASIN MONITORING DATA
LOCATION SPRING STREET
EVENT DATE 12/28/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	430	267.2	143.6
	1.0	155	184.7	48.5
	5.0	156	64.8	29.5
	10.0	110	132.2	25.0
	15.0	106	23.2	-
	20.0	120	143.5	115.1
	30.0	155	230.2	73.3
	40.0	130	253.3	101.2
	50.0	107	142.4	30.9
EFFLUENT	1.0	1073	819.3	131.2
	15.0	118	1006.9	100.4
	30.0	120	1144.4	97.0
	45.0	96	533.4	57.6
	60.0	73	447.1	46.7
	75.0	98	2350.0	109.8
PRE-SUMP		-	-	-
POST-SUMP		-	-	-

* Time since start of storm

TABLE 17. CATCHBASIN MONITORING DATA
LOCATION BAKER STREET
EVENT DATE 12/28/79

SAMPLE TYPE	SAMPLING TIME* (minutes)	COD mg/1	TSS mg/1	VSS mg/1
INFLUENT	0.0	370	1574.9	1113.3
	1.0	346	1202.8	730.3
	5.0	188	591.2	128.2
	10.0	170	759.8	134.5
	15.0	156	285.8	107.3
	20.0	93	477.3	80.8
	30.0	118	168.0	62.1
	40.0	118	206.9	52.0
	50.0	80	235.5	90.8
EFFLUENT	1.0	163	118.9	69.3
	15.0	123	92.0	29.7
	30.0	78	82.8	43.8
	45.0	73	54.6	31.3
	60.0	70	82.8	43.4
	75.0	63	67.9	33.5
PRE-SUMP		-	-	-
POST-SUMP		-	64.7	29.7

* Time since start of storm

TABLE 18. CATCHBASIN MONITORING DATA
LOCATION GLENHAVEN ROAD
EVENT DATE 12/28/79

SAMPLE TYPE	SAMPLING TIME * (minutes)	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	258.	6167.3	4245.2
	1.0	170.	343.7	67.0
	5.0	-	-	-
	10.0	-	-	-
	15.0	70.	45.7	14.6
	20.0	45.	18.1	5.8
	30.0	49.	57.7	19.7
	40.0	-	-	-
	50.0	2.	51.2	13.5
EFFLUENT	1.0	137.	164.1	55.1
	15.0	95.	110.3	35.8
	30.0	58.	79.6	31.7
	45.0	25.	60.9	32.5
	60.0	35.	50.9	28.1
	75.0	18.	34.4	16.7
PRE-SUMP		-	14.6	12.0
POST-SUMP		-	55.3	27.1

* Time since start of storm

TABLE 19. CATCHBASIN MONITORING DATA
LOCATION SPRING STREET
EVENT DATE 1/11/80

SAMPLE TYPE	SAMPLING TIME * (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	225	968	31558.5	8211.8
	2.0	70	757	5044.8	723.1
	10.0	11	238	1808.1	153.0
	20.0	22	238	3292.2	177.5
	30.0	5	95	351.8	52.1
	40.0	5	118	256.2	46.1
EFFLUENT	2.0	65	730	569.4	247.0
	10.0	33	213	217.7	65.3
	20.0	80	382	89.5	49.9
	30.0	43	213	74.5	40.7
	40.0	38	118	52.8	37.6
	50.0	21	118	98.8	49.0
PRE-SUMP		7	48	15.9	4.9
POST-SUMP		16	-	115.2	28.1

* Time since start of storm

TABLE 20. CATCHBASIN MONITORING DATA
LOCATION BAKER STREET
EVENT DATE 1/11/80

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
INFLUENT	0.0	110	863	32250.2	10497.5
	2.0	60	843	3675.1	1173.8
	10.0	16	260	591.8	144.4
	20.0	14	190	598.8	145.4
	30.0	4	143	497.9	100.3
	40.0	3	118	341.9	71.8
EFFLUENT	2.0	33	333	326.5	118.8
	10.0	35	260	259.8	91.0
	20.0	27	188	170.5	61.1
	30.0	26	167	60.3	47.9
	40.0	22	118	76.3	28.9
	50.0	24	118	74.3	26.5
PRE-SUMP		26	70	3.2	1.2
POST-SUMP		7	143	129.4	42.4

* Time since start of storm

TABLE 21. CATCHBASIN MONITORING DATA
LOCATION GLENHAVEN ROAD
EVENT DATE 1/11/80

SAMPLE TYPE	SAMPLING TIME* (minutes)	BOD mg/l	COD mg/l	TSS mg/l	VSS mg/l
PRE-SUMP	0.0	61	757	10550.1	8210.6
	2.0	48	260	429.0	170.0
	10.0	19	238	182.7	56.4
	20.0	25	95	133.1	50.2
	30.0	10	95	127.9	39.9
	40.0	9	70	96.5	36.0
EFFLUENT	1.0	63	188	217.5	64.2
	10.0	62	238	274.3	86.5
	20.0	26	167	307.9	64.4
	30.0	21	118	122.5	32.4
	40.0	18	-	236.4	146.9
	50.0	18	70	93.9	40.3
PRE-SUMP		27	118	36.6	15.8
POST-SUMP		22	358	141.6	44.9

* Time since start of storm

TABLE 22. CATCHBASIN MONITORING DATA
LOCATION SPRING STREET
EVENT DATE 1/14/80

SAMPLE TYPE	SAMPLING TIME* (minutes)	COD mg/l	TSS mg/l	VSS mg/l	TKN mg/l	T-PHOS mg/l
INFLUENT	0.0	885	16251.9	4537.7	14.0	13.60
	10.0	155	546.0	128.0	2.2	9.10
	20.0	107	118.2	29.3	-	8.00
	30.0	70	143.0	26.6	1.2	1.30
	40.0	53	73.1	21.0	-	4.40
	50.0	48	86.5	23.4	1.5	6.40
EFFLUENT	1.0	166	273.4	66.9	1.9	12.50
	10.0	115	205.9	49.5	1.9	5.00
	20.0	45	127.5	30.4	1.5	4.20
	30.0	97	92.9	24.4	1.9	8.10
	40.0	53	85.1	23.2	-	4.00
	50.0	45	59.5	23.2	1.4	3.90
PRE-SUMP		107	52.1	14.1	1.2	6.30
POST-SUMP		95	51.8	13.3	1.1	-

* Time since start of storm

TABLE 23. CATCHBASIN MONITORING DATA
LOCATION BAKER STREET
EVENT DATE 1/14/80

SAMPLE TYPE	SAMPLING TIME* (minutes)	COD mg/l	TSS mg/l	VSS mg/l	TKN mg/l	T-PHOS mg/l
INFLUENT	0.0	578	2364.6	765.3	7.8	7.00
	10.0	143	259.0	109.2	1.7	5.20
	20.0	115	192.7	32.4	-	5.10
	30.0	93	142.9	34.7	1.6	5.10
	40.0	118	119.9	19.7	-	3.80
	50.0	-	78.6	41.7	-	-
EFFLUENT	1.0	215	83.2	28.9	1.8	-
	10.0	190	80.0	26.2	2.2	-
	20.0	137	70.4	26.1	1.9	8.10
	30.0	170	56.1	21.1	1.4	2.50
	40.0	155	60.3	23.8	-	2.80
	50.0	118	208.3	68.9	2.1	1.40
PRE-SUMP		107	27.6	11.6	1.5	2.60
POST-SUMP		188	247.9	82.4	3.0	-

* Time since start of storm

TABLE 24. CATCHBASIN MONITORING DATA
LOCATION GLENHAVEN ROAD
EVENT DATE 1/14/80

SAMPLE TYPE	SAMPLING TIME * (minutes)	COD mg/l	TSS mg/l	VSS mg/l	TKN mg/l	T-PHOS mg/l
INFLUENT	0.0	668.	13445.3	8424.8	11.3	-
	10.0	200.	660.9	104.9	3.7	5.70
	20.0	170.	129.0	45.5	-	7.30
	30.0	162.	98.5	35.7	2.6	-
	40.0	137.	81.9	30.6	-	9.50
	50.0	123.	89.6	38.4	-	8.10
EFFLUENT	1.0	395.	260.0	81.0	7.0	2.80
	10.0	188.	385.9	117.7	5.1	8.20
	20.0	223.	3.8	219.1	72.5	6.30
	30.0	190.	2.9	145.5	54.2	9.60
	40.0	123.	-	111.3	41.6	10.30
	50.0	155.	2.4	106.5	38.4	6.30
PRE-SUMP		73.	1.8	27.8	12.9	5.50
POST-SUMP						

* Time since start of storm

TABLE 25. AVERAGE FLOW RATES FOR RUNOFF EVENTS MONITORED

Runoff Event Date	SPRING ST.	BAKER ST.	GLENHAVEN RD.
	(Flow Rates in cfs)		
12/5/89	0.050	0.025	0.008
12/7/79	0.037	0.022	0.017
12/12/79	0.039	0.018	0.014
12/27/79	0.045	0.027	0.023
12/28/79	0.045	0.015	0.012
1/11/80	0.047	0.023	0.022
1/14/80	0.047	0.022	0.030

TABLE 26. MASS AND PERCENT REMOVALS WITHOUT INLET STRAINERS

		A*	B*	C	D*	E*	F	G*	H*	I	J*	K*	L	M*	N*	O
12/05/79	Spring Street	38120	6309	83.4	4419	360	91.8	3872	394	89.8	579	222	61.7	3484	640	81.6
12/07/79	"	2780	3040	-9.4	330	126	61.8	1630	1450	10.9	343	157	54.2	-	-	-
12/12/79	"	70072	5615	91.9	22092	2177	90.1	4296	2776	35.3	1373	154	88.8	-	-	-
12/27/79	"	88356	2376	97.3	25878	789	96.9	7065	4911	30.5	-	-	-	-	-	-
12/05/79	Baker Street	6657	414	93.8	903	93	89.7	4408	55	98.8	2550	250	90.0	1692	181	89.3
12/07/79	"	3820	336	91.2	2780	827	70.5	1260	700	44.4	161	188	-16.7	-	-	-
12/12/79	"	8353	760	90.9	4920	276	94.4	1363	727	46.6	473	115	75.7	-	-	-
12/27/79	"	8304	3140	62.2	1697	868	48.8	3050	1322	56.4	-	-	-	-	-	-
12/05/79	Glenhaven Road	6.83	75.5	-10.5	71	20	88.5	1340	172	87.2	344	1511	- 339	218	45	79.4
12/07/79	"	1863	581	68.8	252	75	70.2	556	734	-32.0	175	317	-81.1	-	-	-
12/12/79	"	2823	2891	-2.4	2076	574	72.4	443	1430	-22.2	436	177	59.4	-	-	-
12/27/79	"	9540	2594	72.8	6936	905	87.0	2159	1736	19.6	-	-	-	-	-	-

TABLE 27. MASS AND PERCENT REMOVALS WITH INLET STRAINERS

														TKN Inf.	TKN Eff.	% Remov.	TP Inf.	TP Eff.	% Remov.
12/28/79	Spring Street	5498*	35570*	-	28882*	3064*	89.4	5603*	8908*	-58.9	-*	-*	-						
01/11/80	"	135723	4245	96.9	30036	1884	93.8	7743	6823	11.9	1084	1078	0.6	88	40	54.5	172	148	13.9
01/14/80	"	69333	3332	95.2	19190	859	95.5	5307	2056	61.3	-	-	-	-	-	-	-	-	-
12/28/79	Baker Street	6871	922	86.6	3121	464	85.1	2047	1053	48.6	-	-	-	-	-	-	-	-	-
01/11/80	"	59328	1815	96.9	18965	702	96.3	3778	2221	41.2	324	313	3.4	14	20	-42.9	39	17	56.4
01/14/80	"	5901	1022	82.7	1875	357	81.0	2067	1804	12.7	-	-	-	-	-	-	-	-	-
12/28/79	Glenhaven Rd.	7338	762	89.6	4596	305	93.4	885	561	36.6	-	-	-	-	-	-	-	-	-
01/11/80	"	17536	2336	86.7	13036	811	93.8	2306	1632	29.2	262	388	-48.1	32	546	-16.0	79	109	-38.0
01/14/80	"	27109	1204	95.6	16222	5402	68.9	2729	2333	14.5	-	-	-	-	-	-	-	-	-

* All mass units are in grams

Column Reference

A TSS Influent	G COD Influent	M TP Influent
B TSS Effluent	H COD Effluent	N TP Effluent
C % Removal	I % Removal	O % Removal
D VSS Influent	J BOD Influent	
E VSS Effluent	K BOD Effluent	
F % Removal	L % Removal	

related pollutant removals due to the catchbasins were extremely high. Although not measured, it is unlikely that the overall removal efficiencies of the catchbasins would drop to low levels at higher flow rates. Table 27 presents similar results as Table 26 for the events monitored with inlet strainers. The net effect of the inlet strainers was a removal efficiency improvement of 1-10% percent.Nutrient data collected indicated no realizable treatment gain.

Figures 15-18 present typical plots of the catchbasin data. The plots illustrate three important findings; 1) the influent characteristics to the catchbasins were surprisingly consistent over a series of events; 2) no significant effluent "first flush" was observed even though influent levels rose dramatically; and 3) effluent concentrations yielded an almost immediate baseline which the influent gradually tapered to meet.

6.2 Summary of Results-Sump Sediment

As noted in Chapter 5, sump sediment quality and level was monitored prior to each measured runoff event. Figures 19-21 present composite sieve analyses results for Spring Street, Baker Street and Glenhaven Road, respectively. Comparison of these data to other samples collected throughout the United States yields very comparable results. The results of firing each sieved fraction separately, are shown as a residual sieve analysis on the bottom of each figure. The difference between the two curves represents the percent volatile material present in the samples. In all cases, the percent volatile organic matter found was very high for all fractions, averaging approximately 70%.

Table 28 presents the monitoring results of sediment in the catchbasin sumps over the two month evaluation period. As a means of roughly cross-checking the monitoring data, the approximate increase in mass in the sump was compared to the total measured amount deposited in the sump during the runoff events. Assuming that the sump materials have a specific gravity of 1.4, indicative of the mix of sand and organics found, computed accumulations of solids were 111, 117 and 39kg for Spring Street, Baker Street and, Glenhaven Road, respectively. With the exception of Spring Street, these results compare reasonably with the 349, 91, and 56 kg, respectively, deposited during the monitored runoff events (cumulated from Table 27). Although it is difficult due to the limited data set available to predict the exact dry weather additional accumulated load, some dry weather load would have to be added to these numbers. The phenomenon of dry weather accumulation is discussed in more detail in the next section. Even with the addition of a mimimal dry weather load there is reasonable comparability between the

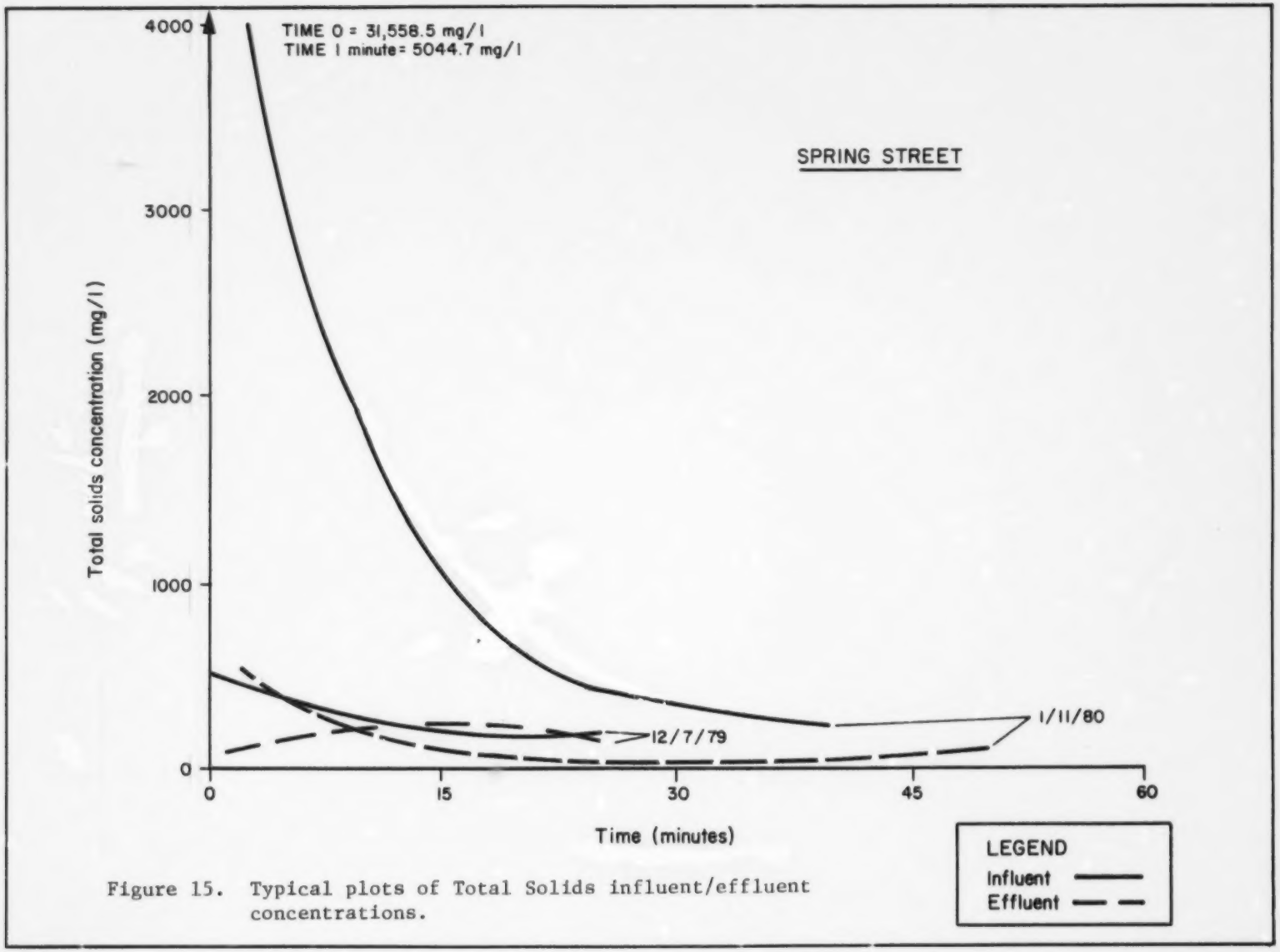


Figure 15. Typical plots of Total Solids influent/effluent concentrations.

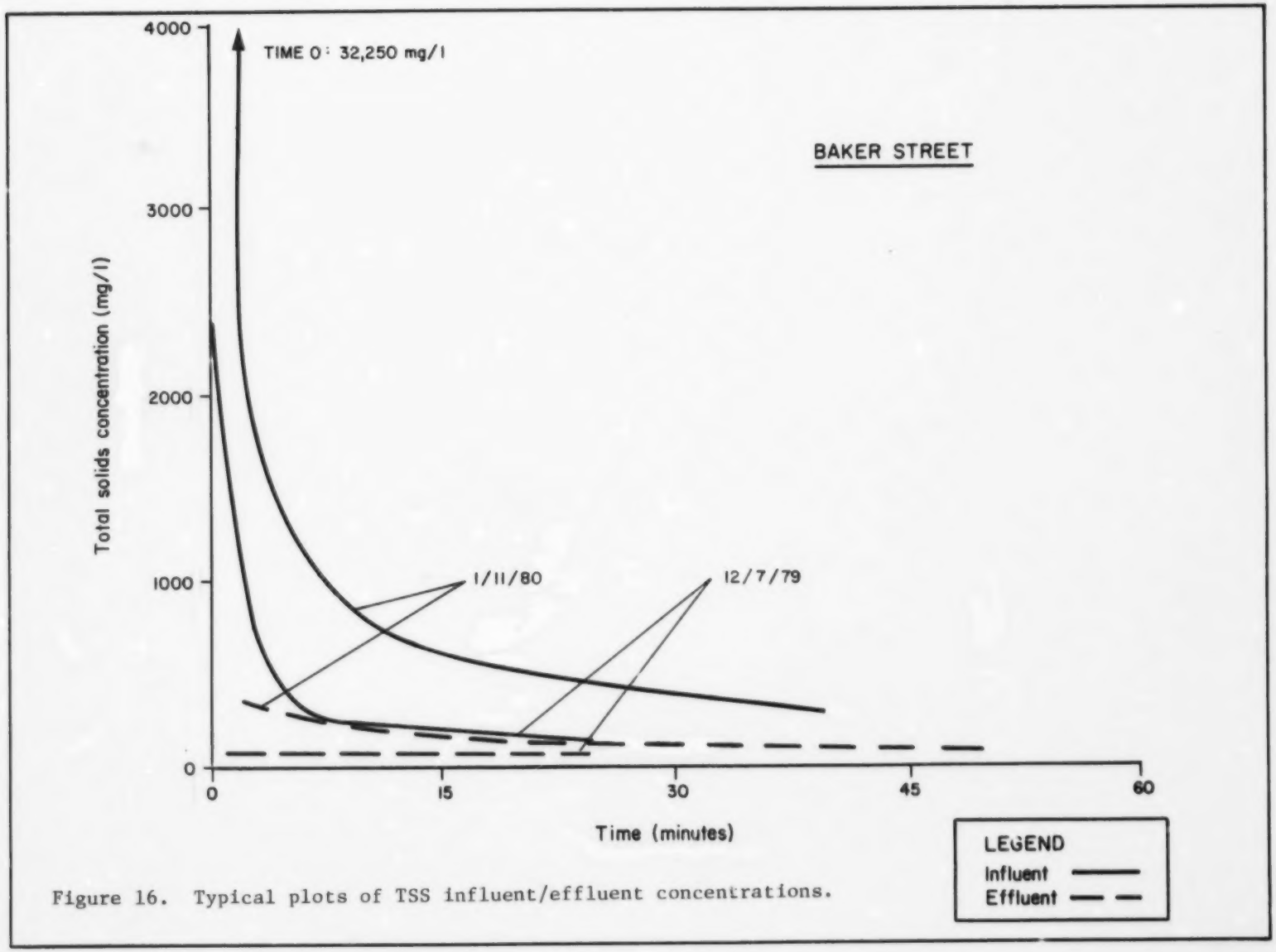


Figure 16. Typical plots of TSS influent/effluent concentrations.

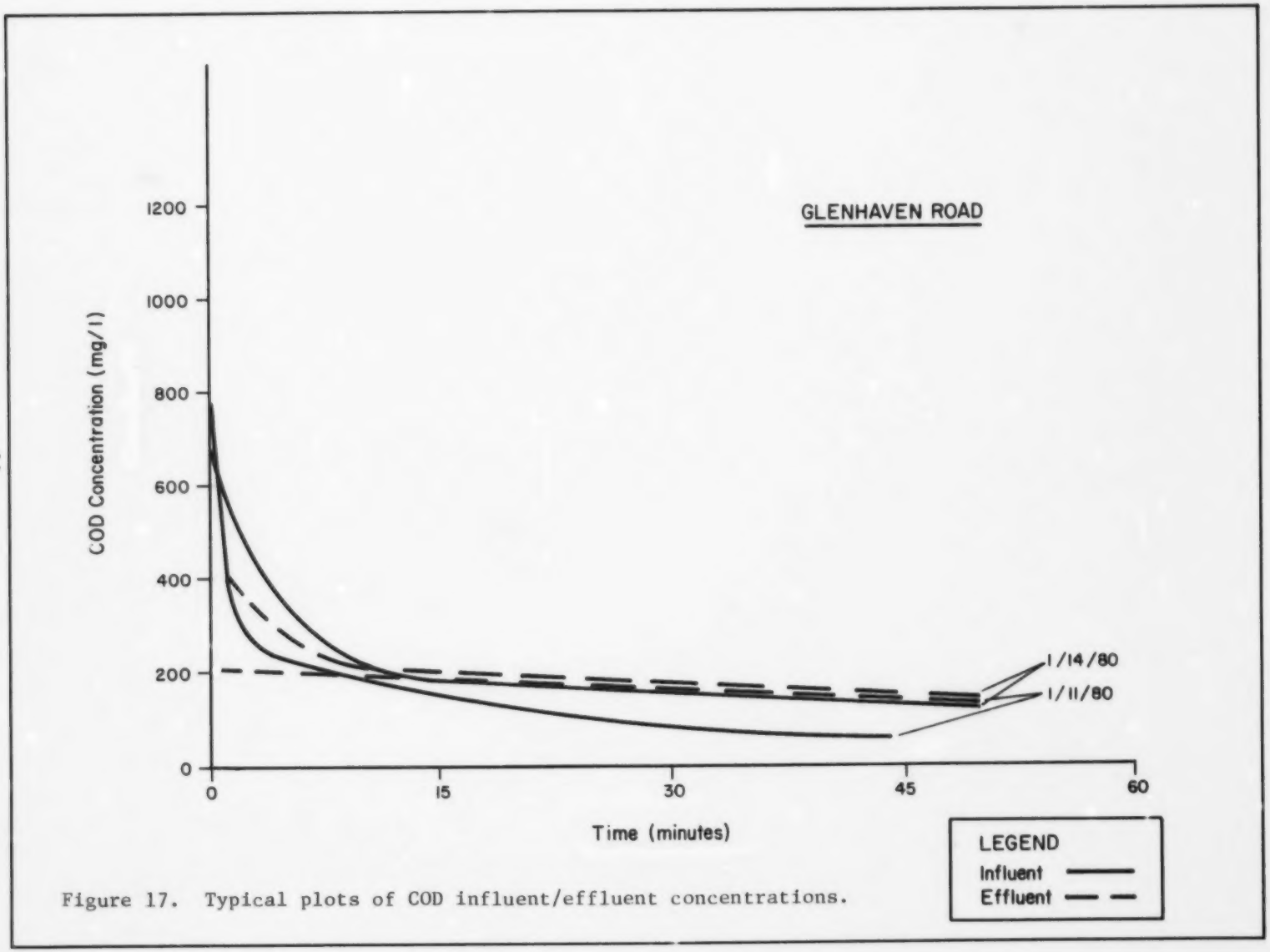


Figure 17. Typical plots of COD influent/effluent concentrations.

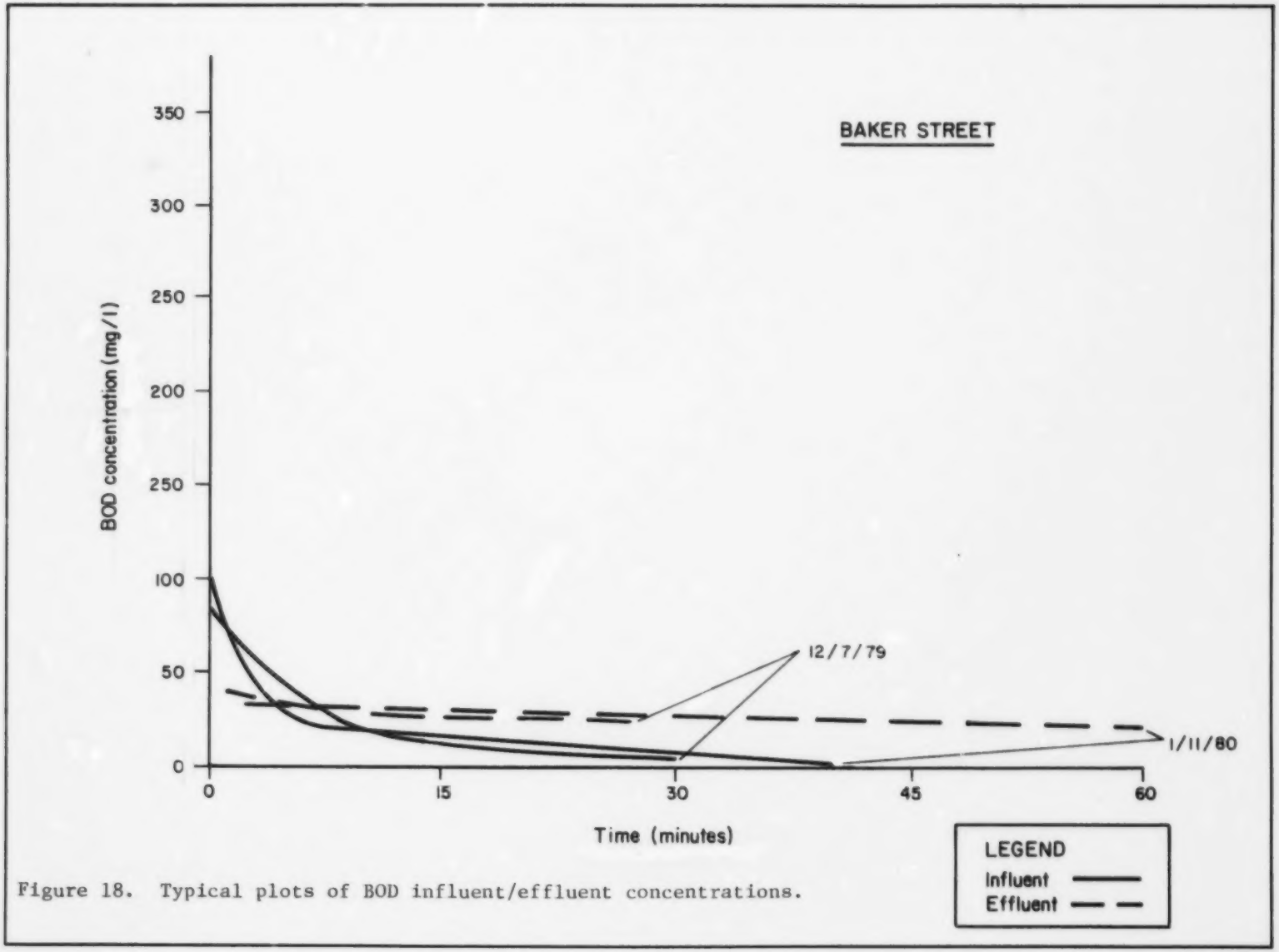


Figure 18. Typical plots of BOD influent/effluent concentrations.

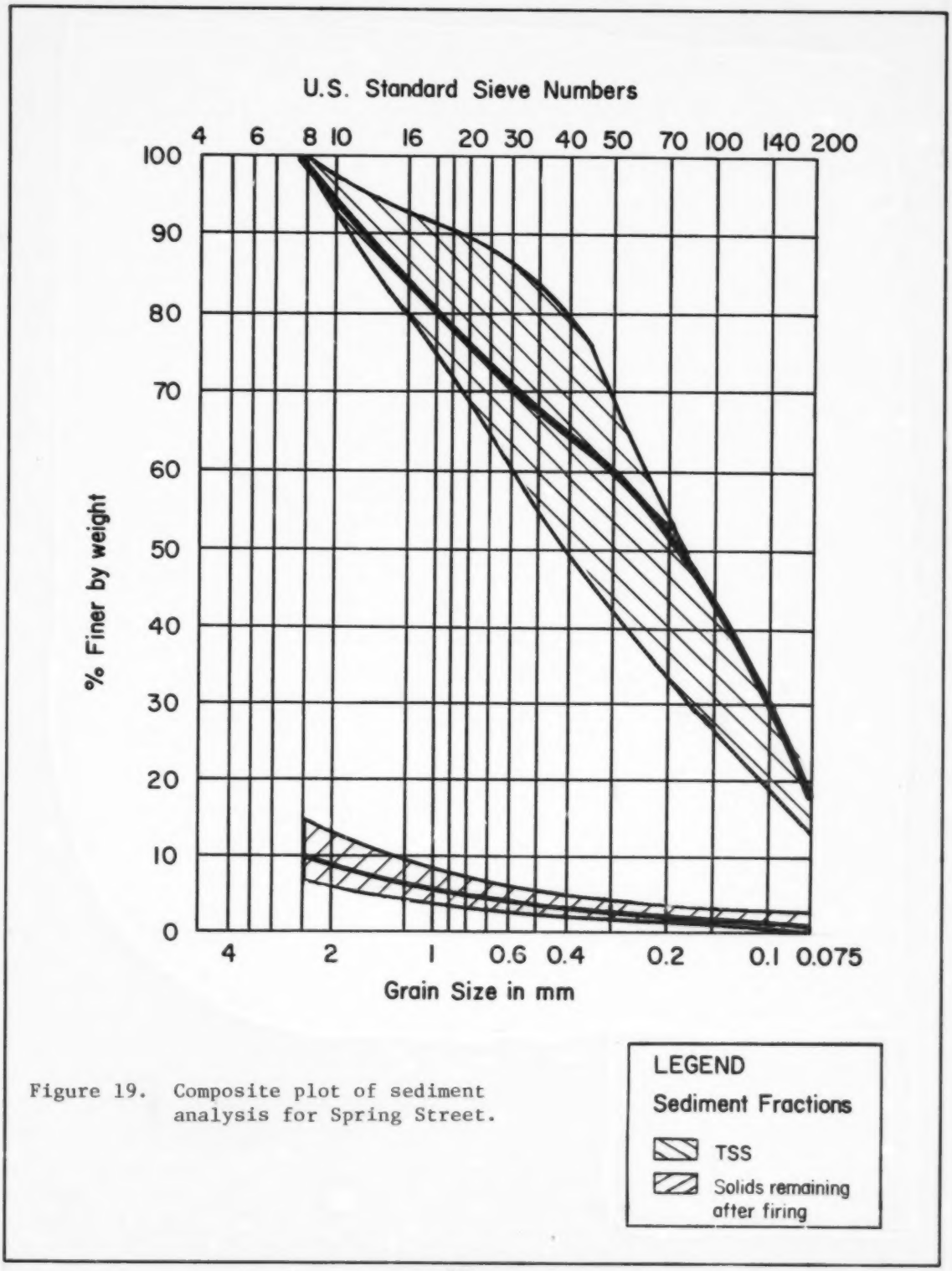


Figure 19. Composite plot of sediment analysis for Spring Street.

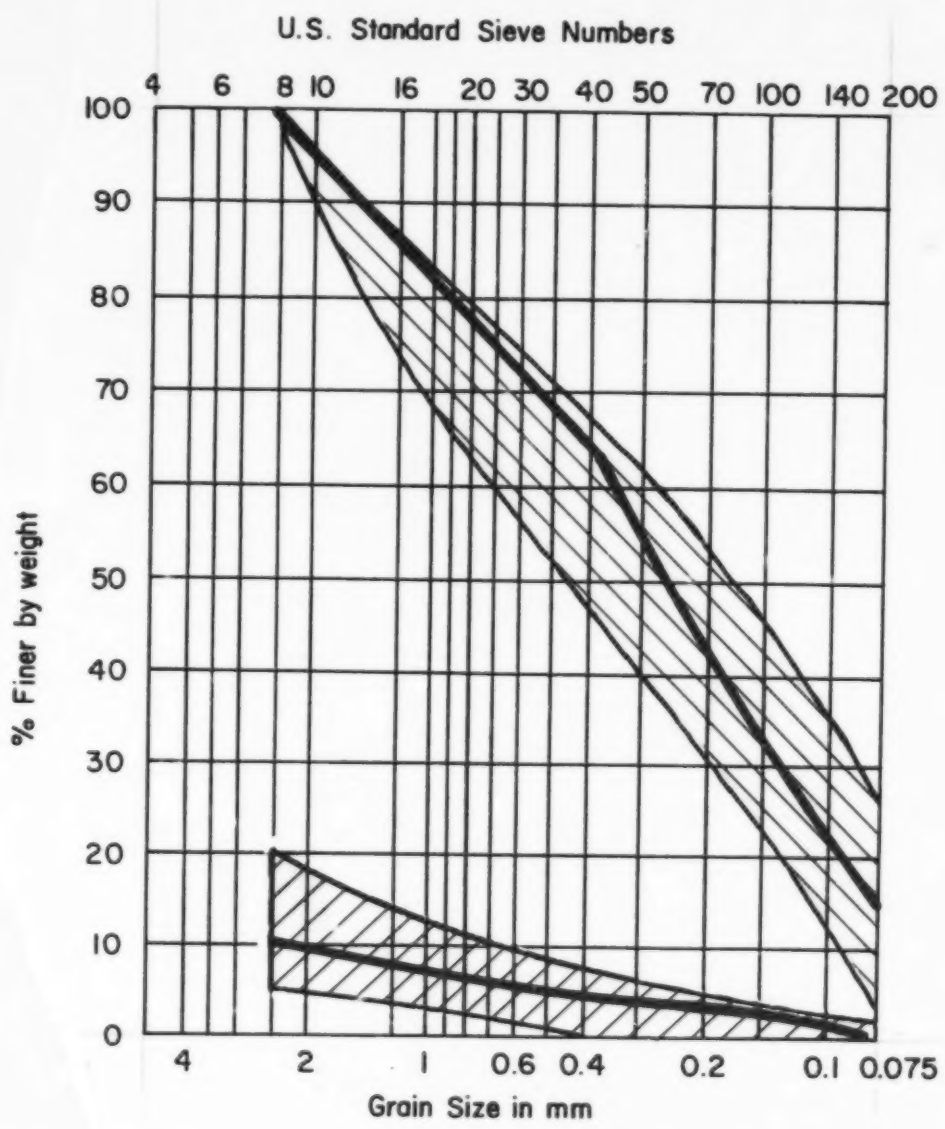

U.S. Standard Sieve Numbers
4 6 8 10 16 20 30 40 50 70 100 140 200
100 90 80 70 60 50 40 30 20 10 0
% Finer by weight
4 2 1 0.6 0.4 0.2 0.1 0.075
Grain Size in mm
LEGEND
Sediment Fractions
TSS
Solids remaining after firing

Figure 20. Composite plot of sediment analysis for Baker Street

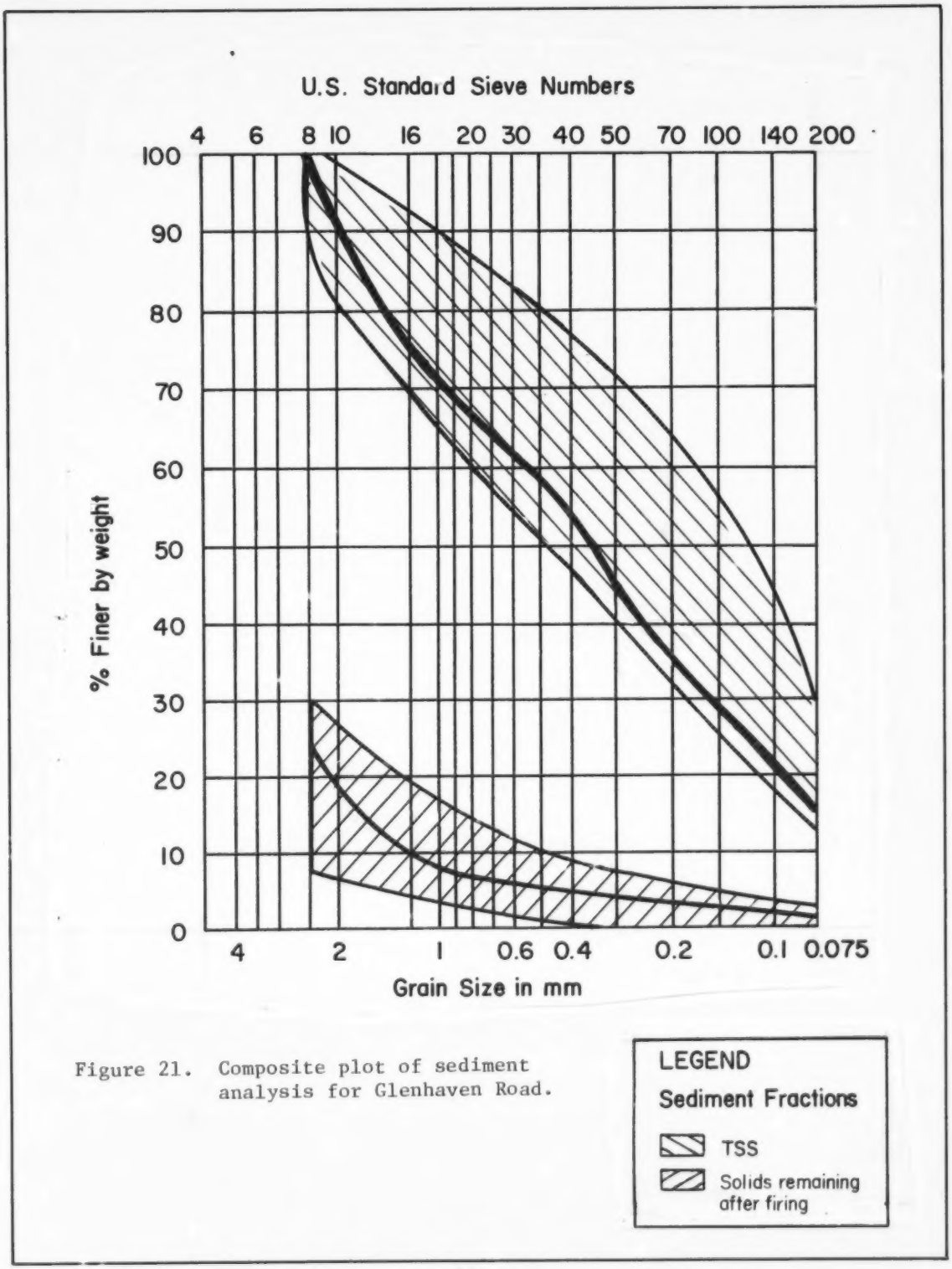

U.S. Standard Sieve Numbers
4 6 8 10 16 20 30 40 50 70 100 140 200
100 90 80 70 60 50 40 30 20 10 0
% Finer by weight
4 2 1 0.6 0.4 0.2 0.1 0.075
Grain Size in mm
LEGEND
Sediment Fractions
TSS
Solids remaining after firing

Figure 21. Composite plot of sediment analysis for Glenhaven Road.

accumulations measured in the sump and, the sum of residuals from the runoff events. This data further corroborates the monitored evidence indicating catchbasin performance to be very high.

TABLE 28

MONITORING OF SUMP LEVELS IN CATCHBASINS

	Level* Spring St. (inches)	Level* Baker St. (inches)	Level* Glenhaven Rd. (inches)
12/5	-	74	70
12/7	70	75	69
12/12	68	71	66
12/27	68	71.25	68.50
12/28	68	71	68
1/11	67.25	71	72
1/14	66.30	71.50	69.50
1/29	66.50	71.50	69.50
Overall increase (inches)	3.5	2.5	0.5

*Indicates distance to sediment from catchbasin rim in inches

6.3 Summary of Results-Influent Strainers

As noted in Chapter 5, inlet strainers were specially designed, constructed and installed in each of the three monitored catchbasins during the last three storm events. As indicated in Table 3, the influent strainers were installed just prior to the runoff event occurring on 12/28/79 and maintained for two weeks subsequent to the final monitored event (until 1/19/80) to give additional data on dry weather accumulations. Table 29 presents a summary of the influent strainer data. Data shown includes; accumulation period (if dry weather), total dry mass of solids collected and percent organic. The inlet strainers collected substantial amounts of materials during dry weather. As may be noted from the data, Spring Street exhibited continuously higher accumulation rates than Baker Street and Glenhaven Road, with significantly more of the matter collected inorganic sand and dirt. This would be indicative of greater wash-off soils loadings from the open areas along Spring Street as well as the much greater traffic density on Spring Street, being a major local commuter road, versus the other two sites

TABLE 29. RESULTS OF THE INFLUENT STRAINER STUDIES

Date	A	B	Total Dry Mass Collected - grams C	D	E	Percent Volatile F	G	H
I. Wet Weather Accumulation (During Event)								
12/28/79		X	1293	5.5	12.2	17.0	68.2	74.3
1/11/80		X	984	556.7	56.7	16.8	34.2	52.3
1/14/80		X	159	214.8	53.8	24.6	60.8	74.4
II. Dry Weather Accumulations (Between Events)								
1/11/80	14		3311	387	102.7	34.2	65.8	70.4
1/14/80*	2		3246	245	718.7	22.9	57.8	71.8
1/29/80	15		1758	539	194.0	24.0	54.2	76.2

Legend

A - Antecedent dry period days
B - Runoff event
C - Spring Street
D - Baker Street
E - Glenhaven Road
F - Spring Street
G - Baker Street
H - Glenhaven Road

* Heavy accumulations due to high intensity short duration storm evening of 1/11/80 0.49 inches rain.

being primarily residential. The major fraction of collected materials from Baker Street and Glenhaven Road was organic leaves and decomposing lawn clippings, as exhibited by the high organic content.

Pollutant removal of the influent strainers during storm events was small in relation to that removed in the sump during the same event, ranging from two to ten %. During dry weather significant accumulations were observed in the inlet strainers, but these accumulations by weight were small in relation to the mass removed in the sump during a storm event. Although, the design size of the inlet strainers used in this program was set at an initial number 8 mesh, (0.0937 in. 2.36mm) this size could have been reduced to gain greater removals. Even so, it is unlikely that the overall efficiency of the units would be great enough to warrant their wide spread use.

The reasons for this conclusion are twofold. First, the inlet strainers detain large amounts of materials, forming a filter cake of progressively finer opening as deposition occurs. This phenomenon would lead to rapid clogging and subsequent localized flooding due to blockages of the catchbasin inlets. It is estimated that required maintenance frequency of the inlet strainers would be weekly making overall maintainence costs high. Secondly, detained materials in the inlet strainers are subject to decomposition between storms as are materials in the catchbasin sump. Unlike the catchbasin sump, the materials in the inlet strainers are held above the overflow outlet making them available for dischage during the next runoff. Organics entrained in the inlet strainers would tend to break down to fine settleable and colloidal particles unsuitable for removal by the catchbasin sump. In contrast, decomposing materials in the catchbasin sump would tend to migrate into the pores between the grit particles. The overall result of a poorly maintained inlet filter, (over one week in cleaning interval) could be local flooding and increased pollutant discharge to the receiving sewer due to build up and decomposition in the strainer.

6.4 Review of Catchbasin Monitoring Data

The catchbasin monitoring program collected a large amount of simultaneous performance data on three test catchbasins in the West Roxbury section of Boston. The catchbasins were divided into two types, direct discharges from the gutter into the receiving sump and discharge to a transmission sump prior to the receiving sump. The latter type, as shown by the Spring Street catchbasin, offers seemingly better energy and thus turbulence dissipation. However, this could not be verified by the performance data, in that removals from all three catchbasins were comparable.

The effects of higher traffic density were dramatically illustrated in the very high influent levels monitored on Spring Street, relative to the other two sites. This effect was illustrated during both dry weather, where significant deposition occurred and, during runoff. See study by Saheen.

Initially, pre-sump samples indicated moderate pollutant levels. In almost every case initial effluent concentration levels were less than the measured pre-sump sample, even though the influent concentrations rose dramatically at the same time yielding no significant "first flush" effects. Overall solids related pollutant removals were generally quite high with few exceptions, although periodic negative removals or flushout were observed for all parameters except VSS. Catchbasin removals for nutrients generally were negligible to negative, indicative of the transfer of nutrients from being bound in solids in the sump to dissolved, after decomposition in the sump.

Sediment accumulation analysis indicated that the materials deposited in the sump at a rate such that cleaning every six months to one year, dependent on conditions, would maintain observed pollutant removals. Analyses of the sump sediments yielded data consistent with that generated in other cities. No appreciable difference was observed in the sediment characteristics between the initial sample (old material left as residual of cleaning operations) and those collected after significant fresh deposition.

Inlet strainers collected substantial amounts of dry weather and runoff induced solids, but their overall effectiveness and potential for widespread utilization was deemed limited by high maintenance requirements vs. limited pollutant removal gains.

CHAPTER 7

CATCHBASIN CLEANING COSTS IN CITY OF BOSTON

7.1 Foreword

In this chapter excerpts from an analysis conducted on the City of Boston sewer system for the Boston Water & Sewer Commission (BW&SC) by EDP are presented (12). Average maintenance costs for cleaning of catchbasins (based on present operating data) are presented in section 7.2. The costs generated were then compared to data for other cities of similar size and weather conditions in section 7.3. In section 7.4 the relative economics of increased catchbasin cleaning frequency are assessed using Boston data for combined sewer systems.

7.2 Boston Catchbasin Cleaning Costs

Cost estimates were generated for cleaning of catchbasins as presently being conducted by BW&SC crews. Costs were broken down into four categories: labor (including overhead), energy usage, vehicle and equipment maintenance, and finally, disposal costs. The break-down and total cost figures are sumarized in Table 30. Rates of catchbasin cleaning were obtained from the analysis of crew performance data supplied by BW&SC and through direct observation of cleaning operations by EDP personnel.

After careful review of labor rates with the BW&SC financial division, labor costs were estimated at $8.83 per hour for catchbasin cleaners. These average figures include overtime and burdening factors. Under present conditions an average of 5.2 catchbasins are cleaned per man per day. The resulting labor cost is $13.60 per basin cleaned. This cost is a citywide overall average based on 1979 reported results and includes travel and paid break-time.

Energy costs are based on average vehicle fuel usage. Catchbasin cleaning trucks were determined to average 10 gallons per day based on BW&SC reported volume data. Fuel was estimated at $1.25 per gallon.

Fuel costs could not be linked to miles traveled due to the large idling times and usage of fuel for operating cleaning machinery. Resulting energy costs were $2.40 per basin.

Vehicle and equipment maintenance costs were more difficult to estimate. Maintenance costs were estimated to be proportional to vehicle fuel costs. A proportionality constant of 2 was determined by examining the expenditures for 1980. For 1980

the following figures were determined for the entire 144 vehicle BW&SC fleet:

Maintnenance	$200,000
Insurance	75,000
Fuel	148,000
	$423,000

Resulting maintenance costs are $4.80 per basin.

Disposal costs can and do vary rapidly. In the fall, 1980, the BW&SC was forced to change its dump site. The new (temporary) site charges $15 per dump, regardless of the size of truck.

An analysis of catchbasin dimensions of approximately 80 catchbasins representatively scattered throughout the BW&SC sewerage system indicated that the average sump and total volumes equal 2.4 and 3.6 cubic yards (1.83-2.75 cubic meters), respectively. Disposal costs range from $7.20 (sump filled) to $10.80 (entire basin filled) per cleaned catchbasin using an average catchbasin cleaning truck volume of 5 cubic yards (3.81 cubic meters).

As shown in Table 30, average Boston catchbasin cleaning costs range from $28.00 to $31.60.

7.3 Boston/National Catchbasin Cleaning Cost Comparison

National catchbasin cleaning cost figures vary considerably. The average cost per basin, based on 17 communities with high snow falls, is $15.8 per basin with a standard deviation of $6.8 per basin (ENR = 3000)(1). Cleaning costs per basin are expected to be higher as Boston catchbasin sumps (2.4 cubic yard or 1.83 cubic meters) are larger than the national average sump volume (1) (1.7 cubic yards or 1.30 cubic meters). Based on 10 communities, a national average of $10.4 per cubic yard is reported with a standard deviation of $11.6 per cubic yard (1). For a typical Boston basin, the national average would predict $37 per basin to clean where the basin is full and $25 per basin to clean where only the sump is full. Similar estimated BW&SC costs (shown in Table 30) of $31.60 and $28.00 per basin are within the national averages for comparable situations and techniques. These costs reflect labor, energy, maintenance and dumping charges. No cost of capital investments are included.

TABLE 30. PRESENT CATCHBASIN CLEANING COSTS
(1980, ENR=3000, BOSTON)

	Based on Full Basin Volume ($97\ ft^3$ per basin)	Based on Full Sump Volume ($65\ ft^3$ per basin)
Labor	13.60	13.60
Energy	2.40	2.40
Vehicle & Equipment Maintenance	4.80	4.80
Disposal	10.80	7.20
Total	$ 31.60	28.00

Section 7.4. Economic Analysis of Increased Catchbasin Cleaning Frequency

In this section two typical scenarios are examined using information generated from an analysis of catchbasin cleaning maintenance practices in the City of Boston (12). First, the issue of whether increased catchbasin cleaning frequency in combined sewer systems is worth the benefits of decreased Wastewater Treatment Plant (WWTP) solids handling is examined using a 162 acre (65.6 ha) test area in West Roxbury, Boston. Second, pollutant removal / cost effectiveness of increased catchbasin cleaning frequency practices versus in-line storage and swirl treatment technology is examined. In both cases an existing WWTP is assumed to exist with adequate solids handling capacity.

Case A

Pertinent data used in this analysis are discussed in detail elsewhere (12) and are summarized in Table 31. In that study an empirical catchbasin solids accumulation simulation model was developed and used to estimate solids retained in typical Boston catchbasins as a function of intervals between catchbasin cleaning and solids input during storm events. These results are summarized in Table 31.

If solids are not removed by the catchbasins then the solids will increase both sewer cleaning and solids removal costs at the treatment plant. To address this problem catchbasin cleaning costs were estimated from the previously described BW&SC data for cleaning frequencies of 2, 1 and 1/2 years for the West Roxbury test area (85 basins). Present values were calculated for a twenty year planning period and a 6 1/8% annual discount rate. Present worth of these annual costs over the twenty year period for the West Roxbury test area are $15,200, $23,300 and $48,500 respectively for cleaning intervals of 2, 1 and 1/2 years.

Storm sewer cleaning costs in the West Roxbury test area estimated for comparison with catchbasin cleaning costs. For the estimate it was assumed only lines 24 inches (61 cm) and larger would need to be cleaned. (1) Average cleaning of storm sewers in the entire system in the West Roxbury test area is $18,500 (1980, ENR = 3000). Present values were calculated for the West Roxbury cleaning operation based on a cleaning frequency of every 10 years and every 5 years for the 20 year planning period and 6 1/8% discount rate. (1) The present worth of sewer cleaning once every ten years is $21,500 (1980, ENR=3000). The present worth if cleaning is needed every 5 years is $42,900.

TABLE 31. PERTINENT DATA - WEST ROXBURY, BOSTON TEST CASE

Pertinent Data - West Roxbury, Boston Test Case

A. Watershed Characteristics

- Area = 105 acre (42.7 ha) single family residential and 55 acre (22.41 ha) open space.
- Runoff coefficient residential area = 0.45
- Curb/gutter density = .097 miles/acre (0.38 km/ha)
- No.catchbasins = 85 (1.24 basins/acre or 3.05 basins/ha)

B. Catchbasin Dimensions (Average)

- Sump volume 64.8 ft^3 (1.84 m^3)
- Total volume 97.2 ft^3 (2.75 m^3)
- Total depth 7 ft (2.1 m)

C. Catchbasin Cleaning Costs
(Boston, 1980, ENR = 3000)

- 2 year frequency - $31.60/cleaning (97 ft^3 removed)*
- 1 year frequency - $26.25/cleaning (49 ft^3 removed)
- 1/2 year frequency - $25.15/cleaning (39 ft^3 removed)
- Assume solids density - 110 lb/ft^3

D. Storm Sewer Cleaning (Test Area)
(Pipes exceeding 2 ft (0.6 m) diameter)

- Footage = 4837 ft (1475 m)
- Average cleaning cost = $3.83/ft ($1.17/m) (1980, ENR = 3000)

E. WWTP Solids Handling Costs

- Operational costs for thickening, vacuum filtration, disposal & maintenance: $193-$581/ton solids handled ($175.5 - $528.2/metric ton solids handled (Boston, 1980, ENR=3000)

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* Determined from empirical catchbasin performance model (12)

WWTP solids handling costs were included for comparison with solids removal through catchbasin cleaning. It was assumed that the WWTP solids handling capacity was adequate, that is, solids loading changes caused by varying catchbasin cleaning policies would not require new facilities. Only the operating costs would be increased by an increasing solids load.

The greater Boston area presently has two major wastewater treatment plants. Plans are being implemented for facilities to reduce sludge volumes and prepare sludges for land disposal. Stormwater treatment plants have also been constructed such as the Cottage Farm facility and plans are being developed for major stormwater treatment facilities throughout the area including the BW&SC service area. Due to the dynamics of the system it was deemed appropriate to examine the range of sludge handling costs nationally in terms of establishing general operating policies for Boston.

Costs indicated in Table 31 include pumping, line stabilization, in some cases thickening either by gravity or vacuum, transportation, disposal, and maintenance of the disposal facility. Costs are operational only; no construction costs are included. The cost range is for a city with 25,000 combined sewered acres.

It was assumed that all solids captured by a catchbasin under a given cleaning policy would be captured by the WWTP under a less efficient catchbasin operating policy. Zero loss to overflows was assumed. In addition, ten percent of the removable solids escaping the catchbasin were considered as deposition and removed by sewer cleaning. The WWTP solids handling costs for different catchbasin cleaning policies are presented in Table 32.

Comparisons between cleaning frequencies and WWTP solids loadings were made for catchbasin cleaning frequencies of 2,1 and 1/2 years. The results are presented in Table 33. The two year frequency would plan to clean relatively full basins. The 1 year frequency would only have sump volumes to clear. The 1/2 year frequency would maintain the basins below the performance breakthrough curve at all times. Cost estimates were made using both the low and high range WWTP solids handling figure. The effect of increased sewer cleaning needs was simulated by assuming a decrease in catchbasin cleaning frequency that would double the need to clean sewers. The "no sewer cleaning" assumption is also included. These results are also presented in Table 33.

TABLE 32. WWTP SOLIDS HANDLING COSTS W. ROXBURY CASE EXAMPLE

Catchbasin Cleaning Frequency (years)	Annualized Weight Solids Removed per Catchbasin (lb)*	Annualized Weight Solids Arriving at WWTP per Catchbasin** (lb)	Annual WWTP Solids Handling Cost per Catch -basin $193/ton-$581/ton	Total Present Value*** Solids $193/ton
2	5335	3485	$336.30 $1012.39	324.5-976.7
1	5390	3430	$331.00 $ 996.42	319.3-961.3
1/2	8580	240	$ 23.16 $ 69.72	22.3- 67.3

* See part C Table 31; also total annual solids input per catchbasin = 9800 lb.

** Note 10% of solids escaping catchbasin deposit in sewer lines

*** 6 1/8%, 20 year planning period

TABLE 33. COMPARATIVE ECONOMICS OF CATCHBASIN CLEANING FREQUENCY (BOSTON CONDITIONS, 1980, ENR=3000)

West Roxbury Test Area, Data

Present Value Costs* ($1000)

Catchbasin Cleaning Frequency (Years)	Sewer Cleaning Frequency (Years)	Catchbasin Cleaning	Sewer Cleaning	Solids Handling WWTP**	Total
2	10	15.2	21.5	324.5	361.2
2	5	15.2	42.9	324.5	382.6
1	10	25.3	21.5	319.3	366.1
1/2	10	48.5	21.5	22.3	92.3
2	***	15.2	-	324.5	339.7
1	***	25.3	-	319.3	344.6
1/2	***	48.5	-	22.3	70.8

* 6 1/8% interest - 20 years planning period
** low solids handling rate used ($193/ton)
*** no sewer cleaning assumed

The results depicted in Table 33 indicate that bi-annual catchbasin cleaning in Boston is extremely cost-effective. These results are somewhat biased in that average catchbasin volumes in Boston are much higher than the national average (see Table 31).

Case B

In the prior example no wet weather control of combined sewage other than WWTP control was considered. In this example overall solids removal costs of catchbasin cleaning are compared with the cost-effective results of a recently adopted (1981) CSO Facility Plan in Saginaw, Michigan (13). The new Facility Plan consists of extensive in-line storage coupled with bleedback to a secondary WWTP with ample excess hydraulic and solids handling capacity and 5 major swirl solids separator installations to treat overflows.

Present worth cost (6 1/8% - 20 years) of the new in-line storage program and the operational cost of solids handling at the City of Saginaw's WWTP equals $2.26 million dollars. Annual elimination of wet weather related solids and BOD loadings attributable to this plan equal 2.89 million lb (1.31 million kg) and 0.777 million lb (0.353 million kg), respectively. Overall present worth unit cost per pound solids and BOD removed equal $0.0391 and $0.145, respectively.

Combined present worth costs of the in-line storage program, the five new swirl facilities (less disinfection) and operational costs of solids handling at WWTP equal $12.08 million dollars. Annual wet weather related solids and BOD removed attributable to the combined plan equal 3.955 million lb (1.8 million kg) and 0.907 million lb (0.412 million kg) respectively. Overall present worth unit cost per lb solids and BOD removed equal $0.1527 and $0.666, respectively. Costs for treating the detained combined sewage volume at the WWTP are not included in either set of these calculations.

Overall present worth solids removal unit costs for the 85 catchbasins in the West Roxbury test area equal $0.0669/lb removed, $0.0659/lb removed and $0.0046/lb removed for catchbasin cleaning frequencies of 2, 1 and 1/2 years, respectively.These unit costs reflect the combined program costs of catchbasin cleaning, sewer cleaning and WWTP solids handling given in Table 32. It is clear that the unit cost of solids removal attributable to a biannual catchbasin cleaning program is extremely cost-effective in

comparison to either the in-line storage or in-line storage / swirl solids separator treatment facilities.

Similarly, the unit cost of BOD removal attributable to bi-annual catchbasin cleaning is cost effective in comparison to either in-line storage or in-line storage/swirl treatment assuming that the relative fraction of BOD to solids in materials removed from catchbasins is as low as 4%.

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